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THE STABILITY OF SMOKELESS POWDER.

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The military use of smokeless powder dates from 1886, at which time Vieille introduced into the French service the gelatinized gun-cotton which, with slight variations, constitutes the smokeless powder of all countries to-day. It is true that England, Italy and Germany, for navy powders, mix nitro-glycerine with the gun-cotton to form their several powders, but the basis for all of them is gun-cotton dissolved in a suitable solvent (of which there are several), shaped to the desired form in its plastic condition, and then freed from nearly all of the solvent by drying.

The solvent employed for non-nitro-glycerine powders is a mixture of ethyl ether with ethyl alcohol. The process of eliminating the solvent reduces the former to a negligible quantity, while from 2½ to 6 per cent of the latter remains after prolonged drying. This variation in quantity is a function of the least dimension of the finished grain; its further reduction is extremely difficult, and as will be shown further on may not be desirable.

In considering the stability of smokeless powder we thus have to consider, first, the stability of an exceedingly complex organic material, nitro-cellulose; second, this material in the presence of considerable quantities of ethyl alcohol; third, the instability of the alcohol itself as affecting the integrity of the nitro-cellulose.

The question "Can gun-cotton be made stable?" has been asked many times during the past sixty years. Up to the year 1862 the answer had generally been in the negative, but about this time the process of "pulping" or reducing the fibre to short lengths was introduced, and the operation of purifying the nitrated cotton was so much improved by this means as to establish a new status for this hitherto discredited explosive. However, the question did not assume very great interest until Vieille's invention a quarter of a century later raised the whole subject of the stability of gun-cotton to one of immense importance to the civilized world. Prior to that time attempts to use gun-cotton as a propellant in its fibrous state had failed, and, as an explosive, it could not compete in price or utility with many other compounds.

In this paper the writer employs the term gun-cotton indiscriminately for all forms of nitrated cotton fibre, the principal difference between the so-called military gun-cotton and that designated as "pyro-cellulose" and "collodion-cotton" being merely one of solubility, the dividing-line as to nitration not being well marked.

What is a stable powder? We naturally expect all organic substances to be destroyed through the lapse of time, although we have good examples of the survival of cellulose in the form of paper and papyrus for hundreds of years for the former and thousands for the latter. Nitro-cellulose in the form of smokeless powder seems to have an unfavorable history when the extreme care with which it is prepared is considered. Enormous quantities of it are used in the manufacture of celluloid, photographic films and pyroxyline varnish, and we rarely hear of its spontaneous combustion in these forms, notwithstanding the fact that little or no care is used in storing them or supervising their stability, once they are manufactured.

On the other hand, gun-cotton itself furnishes a perplexing history. While it is generally stored in a wet state and thus its spontaneous combustion prevented, much of it exists all over the world that is kept for years perfectly dry with no untoward results. Messrs. Du Pont of Wilmington have a sample of the original gun-cotton made by the inventor, Schönbein of Austria, which has been in their possession since 1850. This was kept in considerable masses in the dry state until 1894, when it was found that its heat-test had become so low that for safety it was

stored wet. That *unpulped* and therefore imperfectly purified gun-cotton has endured for nearly half a century without becoming alarmingly unstable is a fact that emphasizes our ignorance of the whole subject. Nor is this ignorance the result of lack of study; the greatest laboratories and the most skillful chemists of the world have been devoted to its investigation for years.

Judging from the 25 years' history of smokeless powder, it must be admitted that in the present state of our knowledge of its manufacture, perfectly stable powder cannot be produced. With the most exquisite care in conducting every operation we find that one lot will exhibit signs of decomposition in perhaps two years, while another lot, made as we think under precisely similar conditions, will endure for three or four times that period. This fact constitutes the most baffling phase of the problem, and its lesson needs no elucidation.

If, however, we can produce powder that, stored on board ship, under the exigencies of the service, will remain stable for a period long enough not to demand examination at such frequent intervals as to constitute a burden and interfere with general operations, we may be satisfied. That much undoubtedly has been accomplished. In other words, under the present process of manufacture and system of supervision after manufacture, we may feel a reasonable assurance in regard to the powder on board ship. However, allowing for human error and even negligence, it is interesting at this point to consider just what degree of danger attends the spontaneous combustion of one or several charges of powder in a ship's magazine. Fortunately, the comparatively long list of such accidents that have already occurred abroad removes this question from the domain of conjecture into that of practical experience.

French cruiser *Vauban* in September, 1900, while bound from Saigon to Nagasaki, suffered an explosion at 3.10 a. m. A considerable fire resulted and the magazines were flooded. At 3.40 the fire was subdued. A subsequent examination of the magazine showed that one 9.4-inch powder tank had been burst and its contents destroyed.

French cruiser *Descartes* bound from Taku to Hong Kong. October 25, at 4.20 p. m., an explosion took place in the lower 6.4-inch magazine. Volumes of thick nitrous smoke with jets

of flame rose through the ammunition hoist, at the same time large volumes of gas and flames made their way into the upper magazine through the communicating hatch, which was open. Fifty minutes before this the temperature was taken and found to be 83° F. Moderate sea. Refrigerating apparatus had been running since 8.30 a. m. A subsequent examination showed that the powder in 187 cartridges of the upper magazine was in a bad state and it was thrown overboard. In the lower magazine two cartridges were found empty; the second had its base near to the mouth of the first in the same line. Evidently the firing of the first had exploded the primer of the second. A third lying above the first was found to be full of spongy carbonaceous material.

French cruiser *Forbin*. At 2.30 a. m., April 15, 1905, an explosion quickly followed by a second was heard in the after part of the ship. A column of flame and smoke poured out of the openings of the 5.5-inch ammunition hoists slightly burning four men about the hands and face. The resulting fire was quickly mastered and the after magazine flooded. A few minutes later the smoke had thinned sufficiently to permit an examination of the magazine. It was found that the door had been blown open and the magazine light blown from its frame; the bulkhead opened at a seam. All of the planking and woodwork in the magazine had been burned or shattered and considerable other construction material damaged. Two cartridges had exploded; four were found to be expanded; two shell charges of black powder exploded; five shell separated from the cartridge cases and seventeen other cases damaged.

The *Charlemagne* had an explosion on December 30, 1904, in the 4-inch magazine. Two men who were in it at the time, though injured, escaped and made their way to the sick-bay. The gunnery officers proceeded to the magazine and found it full of smoke through which flames were visible. The door was closed and the magazine flooded. Out of a lot of nine cartridges that had been lying together, two cases had separated from their projectiles and were found lying on the floor, one of them torn into several fragments and the other flattened. Parts of the woodwork had caught fire.

On the French battleship *Jena*: On March 2, 1907, while lying in dry-dock at Toulon, flames shot up at 1.30 p. m. just forward

of the after 12-inch turret. About 12 or 15 seconds afterward two explosions took place, the second following the first almost immediately and described as a "tonnante." The second explosion threw wreckage and debris into the air and inaugurated a series of half a dozen explosions that lasted an hour. The after part of the ship was practically destroyed and a large number of men lost their lives. In this case a black powder magazine adjoined that containing the smokeless, and at the time of the explosion the cover to the opening between them was open.

The British crusier *Fox* and battleship *Revenge* are reported to have found one or more cases in the magazines with their cordite contents burned, the remainder of the contents of the magazines unharmed.

Instances similar to the above can be cited to the number of twenty-five or thirty, including magazines on shore. They all go to show that where smokeless powder is kept separate from black powder, the danger and destruction that will result from a fire in the former are small. The writer has witnessed two magazine fires on shore; one in a brick building containing 9,000 lbs. of black powder, the other in a frame dry-house containing 70,000 lbs. of smokeless. The detonation accompanying the former was indescribable and the destructive effect very great. In the latter case the noise was muffled and low; the building was leveled to the ground, but its materials were not dispersed; whereas the black-powder magazine disappeared entirely.

The very recent case in which the contents of a powder-tank took fire in New York Harbor will be readily recalled. It will be remembered that this tank was part of the cargo of a powder lighter containing many similar tanks and that, although the woodwork of the vessel caught fire, a considerable time elapsed before other powder was burned.

In dwelling on these mishaps the writer has had in view the endeavor to give a clear view of the extent of the danger accompanying the decomposition of powder. If the black powder is stored in separate magazines, it is evident that the chance of ships being destroyed is very remote. That the danger is remote should in no way cause us to relax our vigilance and care with respect to the whole subject; on the other hand, it is well to understand just what the chance is in order that we may not be hysterically misled into costly and cumbersome devices to pro-

tect the magazines. Since a large number of these mishaps have occurred in the French navy, it should be noted that their powder is similar in composition to all other gun-cotton powders; these powders only differ materially in methods of manufacture and care in subsequent supervision. Two of the examples are taken from the experience of the English. They employ nitro-glycerine-gun-cotton colloids, but these in turn have essentially the same temperature of ignition that ordinary gun-cotton powders have.

Nitro-cellulose powders decompose in four ways. First, when ignited in the open air they burn with a clear pinkish yellow flame requiring several seconds for the combustion. Second, when ignited in a gun the time of combustion is hastened by the pressure and the products of combustion differ from those obtained in the open. Third, when ignited in a partially air-tight receptacle, the powder decomposes in a few seconds, giving off large volumes of thick, yellow, acrid smoke, consisting principally of N_2O_4. Lastly, the decomposition that concerns us most—the slow disintegration of the powder that extends through months and even years.

It is outside of the scope of this paper to consider any other than the last mentioned decomposition. As a matter of interest, however, it should be stated that where a more extended conflagration has taken place as in the magazines of the French ships above cited, the third decomposition has to large extent followed the last, and besides the clear burning, volumes of N_2O_4 were given off in abundance. This gas is extremely irritating to the lungs and would impede the suppression of a fire by driving every one from its immediate vicinity.

For the first few years following the adoption of smokeless powder in the French navy, it was thought to be a perfectly stable material requiring no more care in its storage or supervision than had been devoted to black powder. This opinion was sustained by Berthelot and Vieille, men of the greatest eminence in the science of chemistry. About 1896, however, regulations for the supervision of powder were promulgated and in 1901 they were made very stringent. Whether these regulations were carried out or not is another matter.

It is to be noted here that there are men whose views cannot be lightly considered who are of the opinion that colloid powders cannot take fire as a result of their slow disintegration, among them

Colonel Marsat of the Gavres Commission. This distinguished officer has attempted to demonstrate mathematically his view of the question. The writer, however, has removed any doubts he himself may have had on the subject, by placing a 16-ounce bottle lightly corked, containing a quantity of bad powder, in a place where it was subjected to the heat of the sun (but not its rays). The bottle was inspected every morning for a few days. The stopper was finally found blown out from the mouth of the bottle and its contents burned. A sufficient number of similar cases have come within the writer's immediate experience to place the matter beyond argument.

Before taking up the question of spontaneous combustion through slow disintegration, let us consider the possibility of powder being accidentally ignited through other means.

Friction and percussion have been considered as contributing causes to accidental ignition. So far as the former is concerned, no amount of ordinary handling in bulk will ever generate enough heat to raise powder to the ignition point. The rubbing of the grains together does, nevertheless, generate static electricity, and fires from this cause have occurred, but only, so far as is known, in that stage of manufacture where the surrounding atmosphere was heavily loaded with ether and alcohol fumes. As to percussion, the writer has crushed grains placed on an anvil with blows of a heavy hammer until they were reduced to small fragments, when minute particles would explode occasionally, without igniting the mass.

Powder grains are in the laboratory habitually rasped, scraped with glass, turned in a lathe and otherwise cut into fragments and shavings without ever igniting.

The possibility of exploding smokeless powder by accidental discharges of static electricity has often been advanced.

In 1908 a magazine explosion took place in Batuco, Chile, and the board of investigation found that it was due to spontaneous combustion of smokeless powder; Lieutenant-Colonel Delano ascribed the cause to static electricity. The writer believes that the possibility of accidental fires from this cause is exceedingly small, as he has repeatedly driven electric sparks through thin sheets of powder without igniting it. On the other hand, the electric spark will readily explode a mixture of air and ether fumes, or air and alcohol fumes, if the percentage of fumes to air is suf-

ficiently great. Vieille states that the precentage of ether necessary for combustion is 1.98 and for alcohol 3. Taking into consideration the reluctance with which powder parts with its volatiles toward the final stage of the drying process, together with the fact that all measurements show that the percentages of volatiles *in the powder* after the lapse of several years remain practically the same as when first packed, it is probable that these percentages are never reached in the atmosphere of the containing vessel and we may therefore dismiss with reasonable assurance the possibility of ignition from this cause.

Returning now to the subject of slow decomposition, powder that has suffered a distinct lowering of its heat test shows no change either in its appearance or ballistics in consequence. When the process of disintegration has progressed further, the grains take on a new appearance, in some cases becoming brittle and to a certain extent friable; in others the surface of the grain assumes a softer gummy texture. The latter grains ignite with great difficulty and burn at an advanced stage with no greater facility than does sugar. The brittle grains burn quite readily, but not at all with the readiness of good powder, and leave a skeleton of ash of about the consistency of cigar ash. It must be noted, however, that when powder has reached either of these conditions, it is far gone in decomposition and must have long since passed the danger point. In fact, it is highly probable the danger of spontaneous combustion was escaped at some point where the powder still had a fairly good appearance.

Among the gaseous products of decomposition are the lower oxides of nitrogen and their evolution is accompanied by heat which, if not conducted away rapidly enough, may raise the temperature of the powder to the ignition point. There is no doubt that the rate of decomposition is a function of the temperature to which the powder is subjected, and high temperatures thus react badly in two ways; first, they hasten decomposition, and second, they impede the dissipation of the heat engendered by that decomposition. Furthermore, warm powder is much more inflammable than cold powder under any circumstances. So we have three very good reasons why powder should be kept as cool as possible. How cool it must be kept practically to avoid decomposition is an interesting and important question. The writer believes that smokeless powder will decompose at any tempera-

ture, although as good an authority as Mr. Francis Du Pont is of the opinion that at temperatures below 87° F. the powder of to-day is stable.

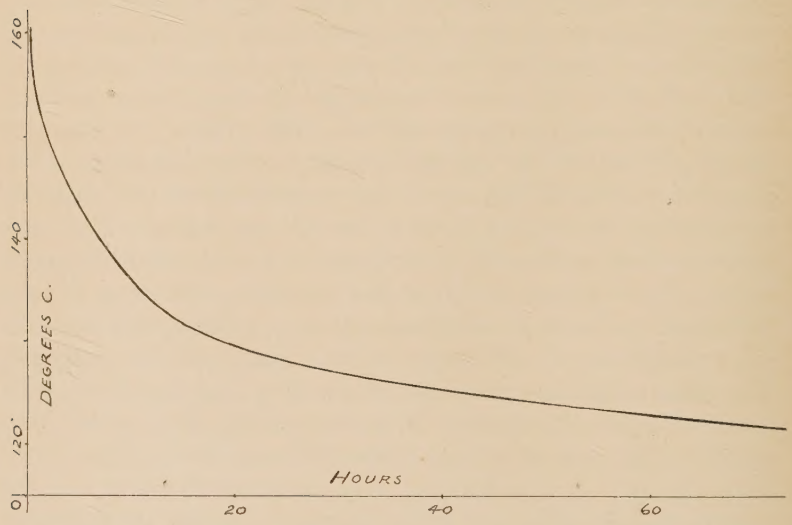
The difficulty of proving experimentally any proposition with respect to the stability of powder lies in the great length of time necessary to complete the experiments. It may take months, but probably several years will be required to demonstrate them. However, an inquiry on the subject of keeping qualities under different temperatures made in France some years ago seemed to indicate, for their powder at least, that stowage temperatures ranging all the way from 104° F. down to 59° F. had given bad results. The powder had been stored in hot sheds and in cool underground magazines, but after a time it was all found to be in a bad state. Of course, heat is not the only factor working against the integrity of the powder. The presence of moisture seems generally to be admitted to have a bad influence. Contamination with chlorine lowers the stability; hence the necessity of avoiding accidentally wetting it with sea water. The sun's rays have an actinic effect on gun-cotton, and alkalis break it down. Above all are the mysterious impurities that seem to have baffled all attempts at detection. How searching has been the investigation may be shown by the fact that causes for instability have been sought in the quality of the fibre; the region in which it was grown; the amount of twist that had been given it in spinning; the ripeness of the cotton; the amount of acids used in nitrating, and so on. This not only illustrates the extent of the inquiry, but also how remote lie the causes tending to the breaking down of gun-cotton.

It has been stated by Mr. Maurice Jaqué that the instability becomes more marked as the extreme limits of nitration are approached. This can hardly be true, since cordite is made up of gun-cotton of high nitration and cordite certainly exhibits no inferiority in keeping qualities to other well made powders.

It is constantly demonstrated in the laboratory that the rate of decomposition is an increasing function of the temperature; but these demonstrations are only made with much higher temperatures than those to which the powder is subjected in storage.

M. Sapojnikoff has made careful experiments in decomposition by heating gun-cotton of three different degrees of nitration, each at temperatures of from 120° to 160° C. and measuring the vol-

ume of gases given off at each temperature. A time and volume curve was then plotted from which it is found that while the curves are generally similar for a given powder, they are too erratic in form to permit of any one equation being deduced to represent the whole process. The curves must be divided into at least three portions. After maintaining a fairly uniform rate, decomposition slows rather abruptly and the evolution ceases finally. It is probable that the danger zone exists during the period of high and regular evolution. I have taken points from his curves of gun-cotton of 12.78 per cent nitration where the amount



of gas has reached 50 cc. at all the temperatures. For this particular set of observations it is at this point that the rate begins to reach a maximum and from these data we are enabled to plot a new curve between temperature and time. In drawing conclusions from this curve we are again confronted by the high temperatures necessarily employed, but if the curve holds good for temperatures from 248° F. down to, say 80° F., as it does from 248° F. up to 329° F., we would then have a definite law for the time of decomposition of any given powder undergoing a certain temperature.

The "*if*" introduced here is a big one, and the writer advances the whole proposition with considerable misgiving. Were we enabled to prove it, the test for any one powder would be to ascertain

where its rate of decomposition under definite temperatures reached a maximum and became regular in order to predict when the powder would need watching in the future under normal temperatures.

It has always been assumed that to make durable powder, gun-cotton of good stability must be used, and the latter must pass rigid tests before it is made up into powder. Dehydration with alcohol dissolves out some of the lower nitrates of cellulose and gets rid of these supposedly unstable bodies. Finally we have in the finished powder gun-cotton and alcohol. Considering ballistic values, it is desirable to reduce the alcohol to as low a point as possible, since it not only acts as a deterrent, causing larger charges to be used, but if it is present in such quantities as to be easily reduced in course of time the velocities increase and the pressures become greater. For stability of ballistics it must therefore be reduced at the beginning, but at the sacrifice of chemical stability since the alcohol seems to preserve the powder by combining with the gases evolved in decomposing powder and thus preventing their assisting in the breaking down process. Under favorable circumstances the alcohol decomposes into acetic acid, but this acid does not affect the integrity of gun-cotton. On account of its higher boiling-point, amyl alcohol has in France been added to the solvent as a preservative. Elsewhere, diphenylamine has been incorporated in the powder with the same object in view.

Unstable powder at no stage down to the point where it is very bad indeed, gives any sign from its appearance of being less than normal. Persons unfamiliar with this fact are apt to suspect powder of being bad from certain flaws in appearance due to harmless accidents of manufacture. For instance, where the gun-cotton has been imperfectly dehydrated it gives an opaque, whitish appearance to the grains. Frequently the first evaporation of solvent after pressing is so rapid as to cool the powder here and there sufficiently to precipitate ether and re-dissolve small portions of the grains, giving them the appearance of having been melted. Again, an excess of solvent in the colloid before pressing causes an undue shrinking of the grains, giving them a shrivelled appearance. It sometimes happens that the die through which the powder is pressed is not working properly and some grains are extruded which have a rough surface. It is the practice

now to exclude all such imperfect grains, but earlier powders contained many of them, and while they probably did not affect the ballistics unfavorably it has been thought best to cull them out.

We come now to the means used for predicting the probable duration of powder in a safe condition. Many methods have been proposed and several are sucessfully employed and they are all based on the assumption that a high heat for a short period will furnish a gage of the amount of destruction that will take place under a low heat for a long period. Whether this assumption is true or not is probably debatable as a general proposition, but the fact remains that the so-called "heat-tests" of which it forms the basis, have for many years supplied us with the principal means of insuring against spontaneous combustion. The heat tests are empirical, and each of the several employed can establish its value by time alone; they all, however, seem to furnish some sort of measure by which we can determine the reluctance with which the atoms part with each other under any stimulus of time and temperature.

Heat tests are divided into two classes—those in which an acid indicator is employed to mark the breaking down, and those which are volumetric in character and measure the rate of evolution of the products of decomposition. A third system, allied to the first mentioned, employs no acid indicator, but marks the visible breaking down of the powder or gun-cotton by inspection.

The well-known KI starch-test has long been used in testing gun-cotton and has been most serviceable. It depends for its action on the liberated nitrous acid attacking the potassium-iodide and freeing iodine which at once changes the color of the starch to a light straw color eventually deepening into blue as the acid fumes continue to react. This test is extremely delicate and an established standard may be changed by thickening the paper used, or changing its texture or altering the arrangement of the simple apparatus that is employed. Moreover, acuity of vision exercises an influence, and no two observers will note the first appearance of "color" at exactly the same time. It is a test that may be easily nullified by the presence of minute quantities of mercuric chloride; besides, other substances interfere with its proper working. Its very delicacy, however, is its best point, since it permits us to conduct a test in less than an hour at a temperature of 150°

F., which is near enough to storage temperature to furnish some idea of what will take place under service conditions. This much cannot be said of any other of the well-known tests. In them we must take for granted the proposition that the behavior of powder at temperatures above the boiling-point of water will provide us means of predicting its action at ordinary atmospheric temperatures. It is a good test for gun-cotton and can be used in testing powder by subdividing the grains in order to increase the exposed surface, as well as to facilitate the evaporation of solvent so that the latter element will not stultify the test.

In the Vieille test the powder is subjected to a temperature of 110° C. (or 230° F.) in a suitably arranged bath. Litmus paper indicates the evolution of acid fumes and when it has turned thoroughly red the test is stopped for the day, the number of hours it has taken to accomplish this result being recorded. Next day the process is repeated and the hours again recorded. The time of heating required grows less daily until finally the test is concluded when the litmus turns red in less than one hour. The sum of all of the hours recorded is then taken as a measure of the number of months the powder may be relied upon to keep in good condition.

While the Vieille test requires considerable time and attention, it has the advantage of not requiring the operator to conduct it except during the ordinary day's work. It is entirely empirical and took years to establish. Mr. Patterson, chief chemist at Indian Head, finds that it gives good parallel results with the KI starch-test and the surveillance test (to be described next), both of which are conducted at 150° F. This, to the writer's mind, is of great importance as tending to establish the validity of the whole system of testing powder by subjecting it to high temperatures.

The surveillance test is one suggested and developed by Patterson. The powder in this test is enclosed in a bottle fitted with a ground glass stopper and placed in a room kept habitually at 150° F. The first appearance of the red fumes of oxides of nitrogen marks the end of the test. The great advantage of this test is that it dispenses with all indicators, while the test temperature is low enough to be at least in the neighborhood of that of the magazines. It has been pointed out how the potassium-iodide test may be easily nullified owing to the delicacy of the indicator. In

a measure litmus suffers from a similar disadvantage. Litmus paper of an exact standard is not easily obtained. While it takes a comparatively long time to determine the degree of stability of powder by the surveillance test, observations need only be made in the daytime. In the writer's opinion it is the best test of which we have any knowledge.

For the largest-grained powders the surveillance test may require two or three hundred days to complete. This does not mean that we are compelled to wait nearly a year before accepting powder. We know that if it survives this test for a few days we can ship the powder and store it without danger. As the time goes on this assurance multiplies, and finally if it takes 8 or 10 months to break it down, we know that in the lesser temperature of the magazine it will be good for several years. If, however, the surveillance sample decomposes before the normal period, the powder in service which it represents is in no immediate danger, and there will be ample time to withdraw it and take proper action. The whole scheme amounts to this: that every lot of powder afloat has its representative stored at considerably higher temperature under constant daily observation.

The so-called German test is conducted at the high temperature of 135° C. Litmus paper is the indicator, and the time it takes to redden it the measure of stability. It indicates the presence of cellulose sulphates with certainty, but as this impurity is readily gotten rid of in the process of manufacture, a test conducted with a lower temperature seems preferable.

To sum up: Powders are made of very great stability and very moderate stability under apparently the same process. At the outset they appear to be equally good by all known tests, and we have no means of prophesying their future. When, as a result of inherent defects or the vicissitudes of storage, they begin tc lower in stability, we have good means of detecting the change and with constant care will be forewarned in time to prevent accidents.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

RANDOM NOTES ON A LAKE FREIGHTER.

By Rear-Admiral Caspar F. Goodrich, U. S. Navy.

For the mariner, one of the most interesting of studies is that of types of ships. From the earliest specimen of which we possess drawings or descriptions down to this day they are, after all, but means to an end. The peculiar design of Noah's ark had in view the purpose for which the vessel was constructed, as the biblical narrative plainly indicates, and the same principle underlies the construction and rig of its successors, whether simple in plan, as the catamaran, the lugger, the schooner, the four-master, or complex as the swift ocean greyhounds which, besides carrying freight and passengers are virtually travelling hotels, and the modern battleship which is both a movable fortress and a floating camp containing a regiment of fighting men. However strange and uncouth many of these craft, ancient and modern, may appear, all are successful or attempted solutions of the universal problem how to devise that which will best yield the result in mind and as such they are worthy of the sailors' consideration. That invariably they offer features which might well be imitated is neither asserted nor believed, for, often, they can better serve as warnings. Yet even this last mentioned circumstance does not detract from their value to him who seeks to know what has been done before him, or is being done by others in analogous fields which, intrinsically, may not concern him at all. Knowledge, even when not strictly pertinent to one's immediate needs, may suddenly prove useful far beyond the cost of the time and money expended in its acquisition. In these reflections may be found an apology for bringing to the notice of my colleagues a water-borne traffic as dissimilar in character and practice from our own experience as may well be imagined. It exhibits, however, two traits that entitle it to especial respect. It is American as to flag and it is enormous as to volume.

Doubtless to many of my brother officers this brief article will seem like the proverbial bringing of coals to Newcastle, for they have lived upon the shores of the Great Lakes and have witnessed, if not the birth, at least, the development of its colossal shipping trade, but the rest of us have never enjoyed this great privilege and our notions, gained through casual report, must be, as my own were until recently, vague in the extreme. Having within the last few weeks enjoyed an opportunity of regarding this fresh-water system at close quarters, it would not appear out of place to lay before my fellows of the Naval Institute the fruits of my inquiries as embodied in notes made on the occasion.

Remembering the saying of the profane old English statesman, that there were lies, blank lies and statistics, I shall only remark that those who are in a position to know estimate the cargo tonnage which passed Detroit and the Sault Ste. Marie in the calendar year 1909, at seventy-two millions, more than three times as much as went through the Suez Canal, and more than twice as much as the total tonnage entered and cleared at the ports of Liverpool and London. Of this amount forty-two million tons were of iron ore brought from Lake Superior to ports on Lakes Michigan and Erie; and seventeen millions were of coal sent north. The balance was lumped under the head of general merchandise, or, as the local expression runs, "package freight." Surely such a vast movement justifies a few words touching the build of the ships that do the bulk of the work and the methods by which they are operated.

In the first place, it must be remembered that the season is ordinarily only eight months long. By the middle of December navigation is closed, to open again about the middle of April. It follows, then, that the most must be made of the period available, hence fairly good speed between ports and the briefest possible delay while at rest are imperative. These conditions having been frankly recognized, dominate the whole scheme. Confining my remarks to the transit of ore, I may point out the necessity at the one end of having that material in readiness on the ship's arrival and so stored as to be loaded into the hold with the utmost dispatch, and, at the other, of discharging it in the least possible time. It is of record that the *W. E. Corey* was, on one occasion, but an hour and a half at Two Harbors from the time of entering until leaving again, having in the meanwhile taken in some 10,500

tons, the exact loading time being 39 minutes. This large cargo was taken out of her in four hours and a half. Such figures seem incredible until the appliances by which they are achieved are examined, when all becomes clear. The *Corey* made thirty-eight trips in one season and transported about four hundred thousand tons of ore.

In some ports a mammoth crane lifts an ore car from the railway tracks, swings it out over the vessel, capsizes it and shoots its fifty tons of ore down a hatch, but usually the ore is held in large bins thirty feet and more above the wharf. From these it is run down in steel chutes about four feet wide, semi-circular in section, which are invariably twelve feet between centres, a constructional detail, that, whether wise or unhappy, must be followed in the spacing of the vessel hatches. However long or short the steamer may be and however wide her hatches, as measured along her midship line, or however broad, measured athwartships, they are exactly twelve (or twenty-four) feet apart from centre to centre, except where deck-houses intervene to make that distance an exact multiple of twelve.

The discharging apparatus is based on the clam-shell dredge, which is lowered into the hold to grab its charge, then elevated, swung back over the dock and emptied into gondola cars, or into carriers that convey the ore athwart the dock and dump it upon piles where is accumulated the winter's supply for the ravenous furnaces of Pittsburg, Cleveland and South Chicago. The latest shape this device has assumed is shown in the accompanying photograph. The long vertical member is kept vertical at all times by means of the movable levers which, with the fixed upright, form a parallelogram. This arm carries the buckets, and can be raised or lowered at will. The buckets, moreover, are susceptible of turning in a horizontal plane about their vertical axis. Through these movements the buckets can rake up the ore in a nearly fore- and aft-line, form a heap and then gather up their huge charge of fifteen tons at a hoist. The operator is stationed inside the vertical member at its lower extremity so that he descends with the buckets into the very hold of the ship for each load. Everything is done by electricity and so complete is the control that the buckets seem to be almost human as they search the corners of the ship and scrape the scattered ore together before seizing it in their capacious maws. Locally these machines are called Huletts after the inventor.

The vessels we are considering are simply floating, self-propelled ore tanks and, as a natural sequence, the entire length is devoted to ore carrying except enough at the stern to contain the boilers, engines and a portion of the crew with their accommodations, and at the bow, more quarters, the wheel-house, steam windlass, etc. When looked upon as an adaptation to a specific purpose they are admirable. In their general appearance, the beautiful has been sacrificed to the useful as this picture of the *J. Pierpont Morgan* will abundantly prove.

The upper deck is flush from forcastle aft, broken only by the transverse hatches (in some cases thirty-six in number) fitted, in the later vessels, with steel covers that are not removed, but which, being telescopic, are simply pulled apart from the mid-ship line by hook ropes taken to winches, the sections sliding over each other and occupying, when thus disposed, but little more room at the outboard end of the hatch, than does one section alone. Stout tarpaulins and handy steel battens are always ready, as with us. During the summer they are seldom used, but he is a foolish captain who should fail to batten down securely, on leaving port during the late fall and early winter, for the lake gales come up suddenly and, at times, they are terrific in violence. The loss of certain freighters has been attributed to neglect of this particular precaution.

This view of the *Edwin F. Holmes* gives a good idea of the customary deck arrangement as well as of ore bins and chutes on the docks which are shown, as seen from above, in the next photograph, which is further interesting from the fact that the steamer photographed has one ore hatch forward of her pilot-house and captain's cabin, or Texas deck, as it is called.

What appears to be, in the *Edwin F. Holmes,* a jack staff out of plumb, is a steering pole. When lowered it becomes a head boom with the steeve of a bowsprit and its extremity lengthens somewhat the distance between the helmsman and the stem, at best unduly short, and thus helps to accuracy in steering on a range.

The engines are habitually triple expansion and the Scotch boiler is still the prevailing type. All lake freighters have but the single screw.

As a rule, the officers and crew are most comfortably quartered. Hammocks are unknown, berths being provided for all.

Steamer "J. P. Morgan," at Superior Dock, Showing New Hulett Unloading Machines.

"J. Pierpont Morgan," One of the Largest on the Lakes.

It is only in length that these vessels can be increased. The draft is inexorably limited by the depth of water at the shallow places between Lake Erie and Lake Superior to about nineteen feet and six inches. The beam might be somewhat greater than the present maximum of 60 feet, the widest that can pass through the Weitzel (American) or the Canadian Lock at the Sault Ste. Marie,* were it not for the loading and unloading now based on a beam not exceeding sixty feet. To alter these would be so expensive an undertaking that we may believe the width of these ships as firmly fixed by man's own doing as is their draft by nature. These facts account for lengths which appear almost grotesque.

Inside, the scheme of design is governed by the desire to make charging and discharging easy in the extreme. Thwartship bulkheads (except such as to divide the hold into separate watertight compartments) and stanchions are fast disappearing in favor of an arch construction which makes each hold an open box-like tank. The stresses on decks and keelsons, as the top and bottom members of the great fore- and aft-girder, must give the naval architects of the lakes much concern. Not being an expert in these matters I can only suggest that possibly the requisite strength in these respects is secured, in part, by carrying the double bottom well up on each side, and by making the spar-deck plates exceedingly heavy. These vessels survive the short seas on the lakes, but it is questionable whether they could ride in safety the longer waves of an ocean gale.

I noticed no trimming of the cargo, which is left in the comparatively low heaps formed by the dumping process. Experience has doubtless proved trimming to be unnecessary. Fortunately the material is heavy and not easily dislodged, else might a shift, when rolling deeply, prove fatal. The Marquette ores, being mined wet and full of jagged lumps, are thus presumably more stable than the more earthy material quarried in the Mesaba region back of Duluth.

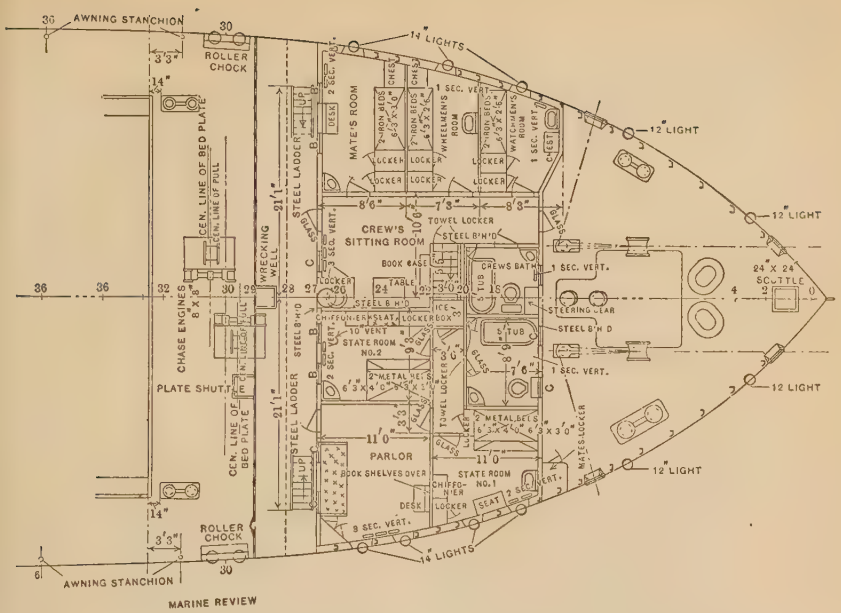
Most, if not all, of these freighters are provided with accommodations for a few passengers, since officials of the owning companies have occasionally to go in them on tours of inspection. During the summer months, a round trip from Lake Erie to Duluth or Two Harbors is extremely enjoyable and is coveted by

* The Poe (American) lock has gates 100 ft. wide.

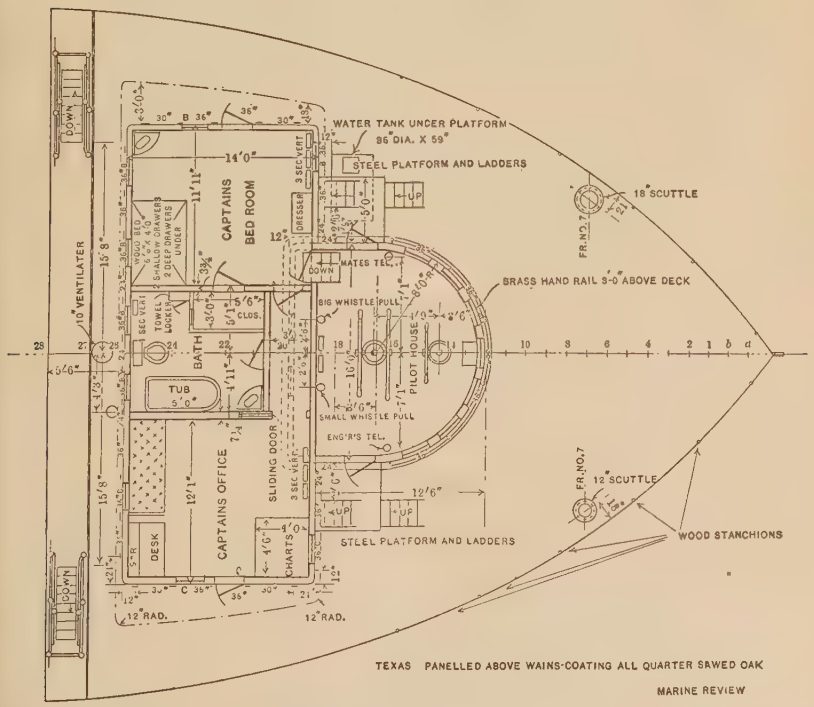
AFTER JOINER PLAN, SPAR-DECK, STEAMER "J. H. SHEADLE," SHOWING CREW'S QUARTERS, GALLEY DINING ROOM AND PRIVATE DINING ROOM.

Loading Ore Boats, Lake Superior.

Steamer Loading, at South Shore Railway Docks, Marquette, Mich.

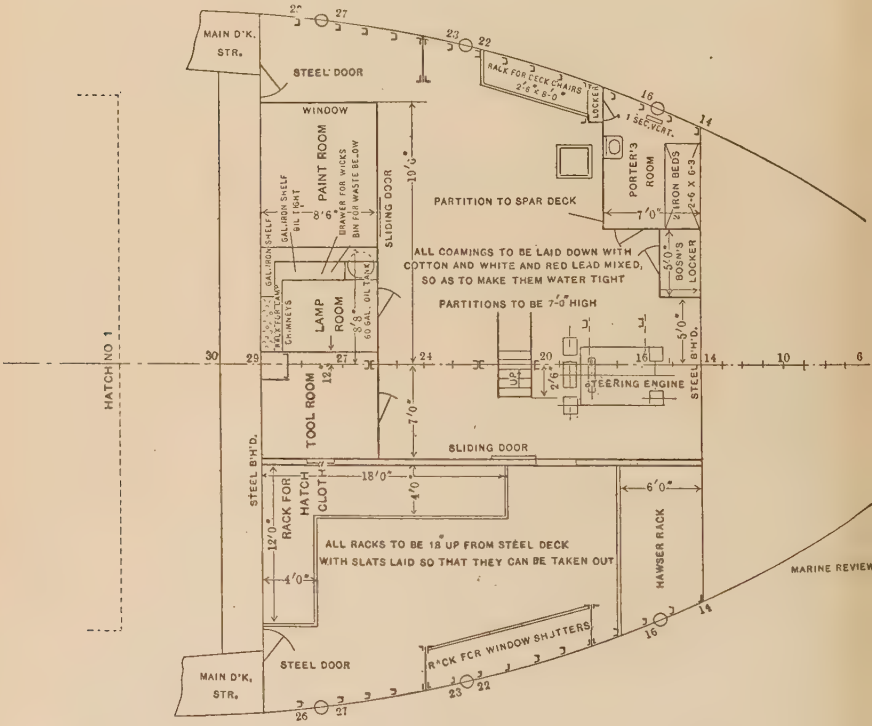


FORWARD JOINER PLAN, SPAR-DECK, SHOWING PASSENGER AND CREW'S QUARTERS ON STEAMER "J. H. SHEADLE."



FORWARD JOINER PLAN, FORECASTLE DECK, SHOWING PILOT-HOUSE AND TEXAS, STEAMER "J. H. SHEADLE."

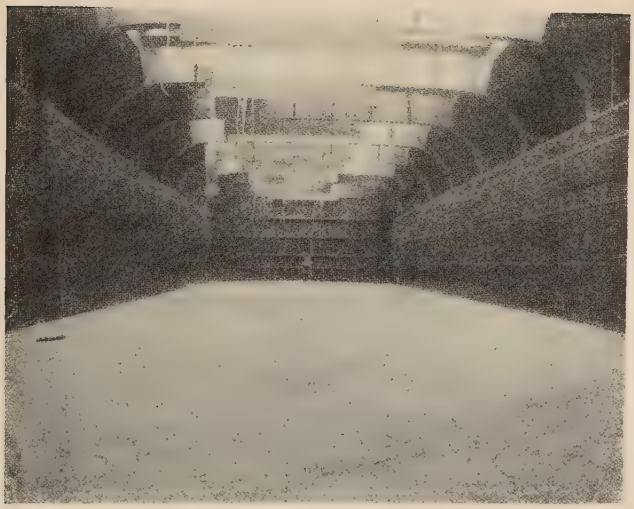
many, both men and women, who possess, or think they possess, some claim on the owner or shipper. Hence, freighters though they be, they seldom go, at this season, without a full complement of guests. The quarters range from the bare comfort of a plainly furnished sleeping room and a seat at the table where, often, all mess, except the firemen and deck-hands, to handsomely equipped private suites and a separate dining room.


MAIN D'K. STR.
STEEL DOOR
WINDOW
PAINT ROOM
LAMP ROOM
TOOL ROOM
SLIDING DOOR
PARTITION TO SPAR DECK
PORTER'S ROOM
IRON BEDS
ALL COAMINGS TO BE LAID DOWN WITH COTTON AND WHITE AND RED LEAD MIXED, SO AS TO MAKE THEM WATER TIGHT
PARTITIONS TO BE 7'-0" HIGH
STEERING ENGINE
STEEL B'H'D.
HATCH NO 1
RACK FOR HATCH CLOTH
ALL RACKS TO BE 18" UP FROM STEEL DECK WITH SLATS LAID SO THAT THEY CAN BE TAKEN OUT
HAWSER RACK
RACK FOR WINDOW SHUTTERS
MARINE REVIEW

DUNNAGE ROOM ON MAIN DECK FORWARD, STEAMER "J. H. SHEADLE."

The *J. H. Sheadle* is among the best examples of the recent additions to the ore-carrying fleet, and I give herewith her deck plans and a photographic view of her hold, that the editor of the Marine Review has kindly consented to my reproducing from a pamphlet entitled "Bulk Freighter *J. H. Sheadle,*" which well merits careful study by sea-faring men.

The personnel of the *Zenith City,* in which I was privileged



Cargo Hold, Steamer "J. H. Sheadle."

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to make the run to Marquette through the politeness of Mr. H. Coulby, the general manager of the Pittsburgh Steamship Co., comprised a captain whose salary may have been about $2200 per annum, a first-mate at 130 per month; second-mate at $90, four wheelsmen and watchmen " at $50; a steward at $90, an assistant at $36; a porter at $30; a chief-engineer at $175; one assistant at $125; one " handy-man " at $65; two oilers and four firemen at $52.50; six deck-hands at $31.50. This, by the way, is the usual complement. The steward is also the cook, and the food he prepares is the same for everybody, from the captain down. Excellent prog it is too—yet it is related that, on board one ship several years ago, before the introduction of " the open shop " and the defeat of the seamen's labor union, the firemen struck because the potatoes were not mashed. The passengers, in this case, happened to be a husky lot who pitched in, shovelled coal and so brought the vessel into port. Comment seems superfluous.

Punishment is by fines, as it should be.

The men ship for the month, or for the round trip, and are paid by checks signed by the captain. As we have too often found among our recruits in the navy, there seems to be a lack of respect for the obligations of the contract of enlistment on the part of these freighters' crews, who make no bones of enlisting in ports of the lower lakes for the purpose of securing a free passage to Duluth and Two Harbors, where they desert at pleasure and take trains for the wheat-fields of the northwest during the harvest season when wages are exceptionally high. This remark applies particularly to the deck-hands, whose work is almost *nil* while underway (they stand no night watch), and who are only really busy when in port, attending to the lines for moving the ship from empty bins to full ones or performing other services connected with the operations of loading and unloading.

It may be observed, by the way, that the absence of tide frees moving alongside the wharf from some of the inconveniences experienced in salt water and that frequent bitts on the dock stringer together with steel lines, with permanent eye splices at the ends, worked from steam winches on the spar-deck, reduces this manœuver to its simplest terms—tossing the end ashore, throwing it over a bitt and heaving in. The winches are four in number, two just abaft the Texas deck and two just forward of the after deck-house; two facing to port and two to starboard.

The language of the sea has suffered material modifications in its translation from the ocean to the lakes. For example: "Aye aye, sir" has given way to "All right," "Ease your helm" to "Slowly," not to mention others equally significant.

Boatswains and their whistles are unknown. Men are called to meals by the "porter" or "assistant steward," who passes along the deck ringing a hand bell. This seems to be quite as effective as the cheery "pipe to dinner" of our service.

Some of the larger companies (the Pittsburgh Company reckons twenty-two barges and seventy-eight steamers in its fleet) are gradually introducing customs similar to those on ocean-going craft, such as striking the half-hours on the ship's bell and restricting promotion to men and officers in their own employ. The Cleveland-Cliffs Co. forbids the latter to appear on shore while attached to a ship in port, except in its prescribed uniform. That an improved *esprit de corps* will be effected by such measures admits of no doubt.

The helpless barge, towed by a collier, is passing out of existence. While an economical method of conveying freight in bulk, as the practice on our Atlantic seaboard abundantly proves, the annoyances attending locking through the Soo and getting alongside of dock, together with the risk of disaster in heavy storms when the freighter's power is barely sufficient for her own needs have acted as discouragements. I cannot say whether the employment of stout, seaworthy tugs has ever been the subject of practical trial. Doubtless this has been thoroughly studied, or these barges, some of which carry eight thousand tons of ore, would not now be in process of abandonment.

As may be imagined, the storage of provisions and of potable water gives little concern since the trips are but three or four days in length between terminals and the navigation is in fresh water.

The speed and all distances are measured in statute miles. About eleven miles an hour empty and ten miles when full seem the average.

The engines rarely develop over two thousand horses, which in heavy gales, when the ship is light and largely the sport of the winds, must cause some uneasiness. The latter inconvenience is neutralized by letting water into the double bottoms. The jet condenser is universal. Despite the poor vacumm it yields (say 22 to 24 inches), these vessels are very economical in fuel. The *Peter White*, with 1560 horse-power, for example, gets one horse-power

for 1.7 lbs. of coal and she burns but 270 tons during the round trip of six days, yet she carries 9000 tons of ore. The *J. E. Upson,* of the same capacity, on the same coal expenditure, develops 1950 indicated horse-power, and makes twelve miles an hour when light.

There are numerous instances of coal consumption of 1.6 per horse-power and even less.

An automatic feed replaces the water tender.

Electric lighting is the rule.

Naturally, external corrosion of the hull and fouling, the banes of our existence, are unknown. The interior of the vessel is either red leaded as with us, or is coated with a special black mineral oil which has proved both cheap and effective.

The steering engine is commonly placed under the wheel. It is, however, also found in the engine room—a better location, of course. I heard some complaint of the telemotor by which this engine is controlled from the pilot-house, and I gathered the impression that captains, as a rule, prefer to have the steering engine directly under their feet.

The handling of these long craft gave me a favorable impression of the skill of their captains. A tug was used at Ashtabula in getting clear of the dock and out into the open lake, but neither the captain nor I thought this assistance necessary on that occasion however valuable when the wind is blowing fresh. At Marquette we ran alongside the wharf as easily as possible and tied up at once. I could have wished more difficult conditions in order to observe better the captain's dexterity, although I have no doubt of his successfully meeting any requirements.

Of navigation, properly speaking, there is no trace on the lakes, for land is in sight the greater part of the time, and determining the ship's position by astronomical methods is quite unknown. The nearest approach is in ascertaining the compass error by the sun's shadow, his true azimuth being taken from tables. On the other hand, coasting and piloting obtain. In the former operation I did not notice the strict keeping of the run as is customary with us and the plotting of the ship's place on the chart from time to time by means of cross bearings, bow and beam bearings and the like. Probably this precaution is thought unnecessary, so frequently do the captains pass over the same ground. That a risk is incurred by not following our deep-water practice I am disposed to believe. The time is always recorded in the log when certain well-known headlands, etc., are abeam, together with the

reading of the engine revolution counter dial. The log book is most simply kept. It contains but the barest story of the run. There are no divisions into watches and several days' proceedings may appear on one page. The columns are marked as follows, viz.: Date, time, place to place, distance off, time from last place, upper compass, lower compass, on the left-hand page; wind, weather, revolutions last six hours, revolutions, place to place, remarks, on the other. Temperature and barometer heights are absent and the remarks column is mainly a blank.

In piloting, these captains are at their best. So far as my observation went they are masters of this art. Much has been done by the Light-House Board to make the passages over difficult points absolutely safe, light-houses, beacons and buoys abound. In narrow places the channel is marked by buoys on either hand, which are lighted at night. It is only a question of keeping between them. Indeed, once entered there seems to be no more difficulty in getting through than of walking down Fifth Avenue. Then, too, under the River and Harbor Acts the government has already spent some fifty millions of dollars in removing obstacles, building locks at the Soo and in cutting long straight channels miles long, sometimes through dry land, to replace the tortuous navigation previously encountered. Again, these artificial waterways are, not infrequently, two in number that vessels may not meet in narrow waters—a double-tracked road so to speak. In addition to the buoys, they are provided with range targets and lights, leading when in line directly down the axis of the channel and furnishing incidentally a rigidly exact method of finding the compass error on that particular heading. A convenient bank book suitably ruled is in use by these captains for entering the observed headings by the standard and steering compasses at no less than sixteen such localities on the Detroit and St. Clavis rivers and twenty-one on the St. Mary's River between Lakes Huron and Superior. There can be no excuse for ignorance of the local deviation. Verbal communication between the pilot-house and engine room is usually by telephone. Signals to the latter are most frequently by the ordinary engine room telegraph, now gradually replacing the small steam whistle once exclusively used. The latter is still retained for cases of breakdown in the telegraph.

A stout trolley wire, carrying a boatswain's chair, is stretched between the bridge and after deck-house. Its value when the spar-

deck is swept by a heavy sea needs no explanation. This appliance is obligatory. Its need was made clear (in 1905) when a certain steamer, the *Mataafa* of the Pittsburgh Steamship Co's fleet, having run ashore in a violent storm, all her crew stationed aft were lost through inability to reach the bow, for there is no passage-way between the ends of the vessel below the upper deck.

Speaking of weather, the late fall and early winter are apt to exact a heavy toll, especially on Lake Superior, with its rock-bound coast, lack of sea room and paucity of refuge harbors. In some seasons the wrecking of steamers and destruction of life are almost appalling. I am confident that some of this is needless, that it might be avoided if captains realized the possibilities which reside in good ground tackle skilfully managed. While very deep, say two hundred fathoms in parts, Lake Superior has a clay bottom with a gradual slope towards the shores. Remembering what anchors did for our blockading fleet, were I caught in a menacing Lake Superior gale, I would shackle both chains to one anchor, and lower the latter down to extreme scope—about 180 fathoms. It would first act as a drag to keep the bow towards the sea, then it would touch the bottom with increased efficiency, finally it would catch in this best of holding ground and eventually bring the ship up long before she struck the reefs. The captains with whom I discussed this matter thought well of the proposition (for the originality of which I disclaimed any credit) and said they would adopt it on the first opportunity. One, Captain Murphy, of the *Peter White,* stated that he had tried it once, but a defective link parted and he was obliged to battle for safety with his engines alone.

Locking through the "Soo" is an interesting operation and performed with great despatch. Two locks are in use on the American side and one on the Canadian. There are no charges. A third and still larger lock is building by our army engineers. The difference in level between Huron and Superior makes a lock imperatively necessary. Doubtless the fact that the lakes' people are accustomed to this unavoidable process accounts for their general approbation of locks at Panama, a feature in our trans-isthmian canal as unnecessary as it is deplorable.

The return to Lake Erie I made on board the *J. E. Upson,* Captain J. G. Wood, through the politeness of Captain Wm. Morton, manager of the Wilson Transit Co., of Cleveland. The steamer herself is among the larger of her kind, but not among the larg-

est, having thirty hatches while the maximum is thirty-six. She is, therefore, seventy-two feet shorter than the *J. Pierpont Morgan*. I found her captain alert and competent, as well as a thoughtful host, and her accommodations almost luxurious.

Speaking in general terms, I should say that the lake captains are quite as skilful in their more restricted employment as our battleship captains are in theirs, which embraces so much larger variety of incidents. Greater praise could not be given. From among the number of these fresh-water sailors excellent men can be drawn to help us out in time of war, for their intelligence is of a high order and they can quickly learn what is not, at present, of their experience.

Some surprise I felt in the absence of turbine engines in these freighters. Doubtless these may arrive some day provided the screws do not project so far from the midship line as to embarrass the operation of getting alongside the docks.

Nor has oil burning been attempted in spite of the proximity of the heavy oil field of Lima and of the advantage of eliminating the fireman, just now well in hand, but liable at any moment to prove, as of old, the source of infinite trouble.

The charts in use, while accurate, presented one feature which is not free from danger. The courses from place to place, as marked, appeared to me, in some instances, to shave the headlands or outlying reefs altogether too closely. In clear weather this is no drawback, but in fogs or thick weather a slight deviation from the correct magnetic heading might run a vessel ashore. It may be argued that a captain ought to disregard the chart course under such circumstances and give the next obstacle a wider berth than a mile and a half. Quite true, but a safer plan, according to my view, is to prescribe a course which will carry the vessel in good water at all times and yet leave a comfortable margin for error, for, being given on a government publication, it is naturally followed by the captain who looks upon it as official.

I am deeply indebted to the gentlemen who were so good as to secure me a most enlightening and enjoyable experience. It is hoped that my random notes may be found readable if not profitable by my colleagues of the naval service. In these days of marvellous and rapid development one never knows when some little scrap of apparently unrelated information may "come in mighty handy."

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

AN UNPRECEDENTED RESCUE.

By CAPTAIN BRADLEY A. FISKE, U. S. Navy.

On September 20, 1906, the U. S. S. *Minneapolis* was off the coast of North Carolina, proceeding from Philadelphia to Havana at sixteen knots speed. We had left the Philadelphia Navy Yard two days before, with two battalions of marines and their camp equipage, because a revolt was imminent in Cuba, and the United States intended to prevent it. Marines and soldiers of the regular army were ordered to Cuba in large numbers and with great dispatch. The marines, of course, got off first; and those on board the *Minneapolis* were the first detachment of the marines. We had four hundred of them; and these, in addition to the regular crew of the ship, made somewhat over eight hundred souls on board.

Shortly before we left Philadelphia, there had been a cyclone to the southward; but this had subsided, and the weather on September the twentieth was clear and pleasant, the only reminder of the cyclone being a smooth and heavy swell.

I turned in about half-past ten that evening. About eleven o'clock, I was wakened from a sound sleep by a vigorous rapping at my door and a voice calling:

"Captain, captain."

"Well?"

"Man overboard, sir."

"Man overboard?" I inquired drowsily.

"Yes, sir."

"Very well, I'll go on deck."

By this time I was sufficiently roused to realize that the night was so warm that I need not put on any warm clothing, and that the gold braid on my cap visor would be sufficient identification

on deck. So I simply put on my cap, and went up on the quarter-deck with no other clothing than my pajamas.

When I got on the quarterdeck, the great darkness prevented my seeing anything at first. But, in a few moments, my eyes became sufficiently accustomed to the darkness to enable me to see that the two life-boats, which hung on each side of the quarter-deck, were already manned; and that what remained of the quarterdeck, where lumber was not stowed, was covered with officers of the ship and marine officers, who, though perfectly quiet, had the air of being astonished at something.

Just then the executive officer, Lieutenant-Commander Stanworth, came up and said:

"Sir, we do not yet know exactly what has happened. I don't think any man has fallen overboard from the ship; but the sergeant of the guard says he heard a man calling for help from the water."

"But the ship has not been stopped," I said; "I hear the engines going now."

"No, sir," he answered, "the officer-of-the-deck put his helm hard-a-port and headed back."

I sent an order to the officer-of-the-deck to stop the ship, and head her in the direction we had come from, and to turn on both searchlights, and search in every direction. I interrogated Mr. Stanworth further, but found that he knew no more of the situation than he had already told me.

There were a great number of officers congregated near, and I gathered from their remarks that they were thoroughly mystified. I asked some of them if they could give me any information as to what had happened, and none of them could; but they all thought that whoever heard the cry for help was suffering from delusion, because, as one of them said, how could there be anybody out here on the ocean at night, more than fifty miles from shore? I then told Mr. Stanworth that I would go on the bridge, and that I wished him to accompany me. I directed Ensign Howe to take charge of one life-boat and Ensign McCommon of the other, and to be ready to go in search of the man, but not to lower the boats until ordered.

On my way forward to the bridge, which, in a ship four hundred and ten feet long took some time, I found the deck full of people conversing in subdued tones. They all stopped talking as

I went by; but I could gather from stray remarks that they were more than incredulous as to there having been any cry for help; and I heard such expressions as, "Oh, the sergeant's got rats;" "He's a ———, ———," etc., all along the decks.

On my way forward, the sudden realization came to me that I was in command of a ship, sent on urgent duty at a critical time, and that I was headed in the wrong direction.

When I got on the bridge the officer-of-the-deck saluted and said, "Good evening, Captain."

"Good evening, Mr. Cooper, what has happened?"

"I don't know exactly, sir; but a few minutes ago the sergeant of the guard, who is a very reliable man, ran up here and reported that he heard a man overboard in the water. So I put the helm hard-a-port and headed back, and now I've got the ship stopped, according to your orders. I've got both searchlights turned on, also, sir."

"So the ship's stopped, and you are headed back in the direction you came from?"

"Yes, sir."

"Where's the sergeant of the guard who made this report?"

"Here, sir;" and the sergeant stepped forward out of the darkness, saluted, and stood at attention.

"Now sergeant, tell me the whole story."

"Well, sir, it had just gone six bells, and I was standing by the port rail of the superstructure deck, about half-way forward, talking to the chief carpenter's mate. All on a sudden, I heard a man right under me, like he was right close to the ship, call out 'help.' I heard him as plain as I ever heard anything in my life, sir. So I said to the carpenter's mate, 'Did you hear that man call "help?"' 'No,' he said. Just then I heard him call again just the same as before, only not so loud, as if the ship had gone by him a little. 'God Almighty,' said the carpenter's mate, those are the words he used, sir, 'I heard him that time.' Then I ran up to the officer-of-the-deck as fast I could, sir, and told him just what I told you, sir; that is all I know about it, sir; but here's the carpenter's mate, sir, and he'll tell you the same as I do."

"Carpenter's mate."

"Yes, sir;" and another man came forward and saluted.

"Did you hear any man call 'help' from the water?"

"Yes, sir."

"Are you sure?"

"Positive, sir."

The sergeant and the carpenter's mate were evidently sober, and they were perfectly calm. I endeavored to impress them with the seriousness of turning back a ship bound on urgent duty; but they both assured me, with the utmost earnestness, that they had heard the cry; and I became convinced that they were at least sincere.

Then I figured out on a piece of paper the most probable direction of the man at the present time, and ordered the officer-of-the-deck to head in that direction, and go at a very slow speed, also to train one searchlight in a direction which I indicated and the other in another given direction; but first to lower the life-boats, and order Howe and McCommon to pull just outside of the searchlight beams.

Then Mr. Stanworth and I stood together on the port side of the bridge, with our night glasses, looking in what we considered the most probable direction in which to pick up the man; supposing there was one.

Before this time the men had been mustered at quarters, and it had been definitely ascertained that no one had fallen overboard.

"What do you think of this, Stanworth?"

"I don't know quite what to think of it, captain. I don't see how a man could be overboard out here. My father was a pilot, and I have been among seafaring people all my life, and I think I've read nearly all the sea stories there are. I never heard of such a thing, but the men seem to be absolutely sure they heard a cry for help."

"I know, but it seems more probable to me that there should be a ventriloquist on board than that there should be a man alone out here on the ocean."

"By George," said Stanworth, "I never thought of that."

When Stanworth said "By George," which was the closest approximation to profanity that he allowed himself, I knew that he was roused from the condition of imperturbability in which he habitually lived; and I enjoyed the occasion accordingly.

The events thus far narrated occupied about half an hour; that is until about seven bells, or half-past eleven. Up to this time, the

rapid succession of impressions kept me interested, and kept my faith alive; but as the moments wore on, and the searchlights brought out nothing but the water, which they illuminated in greenish-white streaks, I began to doubt more and more the wisdom of my action.

About fifteen minutes before twelve, Stanworth said, in his quiet voice:

"I think I see something, sir."

"Where?"

"Near the left side of the beam of the forward searchlight."

I trained my glass in that direction, but could see nothing. Just then the searchlight moved a little to the left, and through my night glass, I thought I saw a little white projection sticking above water, about two points on the port bow.

"I think I see something too."

In a few minutes everybody on deck saw it. "What is it?" came from men scattered all about the decks.

For some time, perhaps five minutes, but it seemed much longer, nothing could be made out of this curious little white elevation.

"I think it's moving, whatever it is," said Stanworth.

"It seems to me," continued Stanworth, speaking very slowly, "that it moves from right to left and back again, like a pendulum upside down."

"Yes, I think you're right," and I directed the officer-of-the-deck to head the ship towards the object at very slow speed.

The object seemed to be quite small, and it evidently did not move with the undulation of the sea; its movement had not the same period; it was quicker. It seemed to me as if it must be either a man who was moving from side to side, or else something that was moved by some kind of engine. The movement was perfectly regular.

"By George, sir," exclaimed Stanworth, "I believe it's a man using a paddle! Now watch, and see if you don't see the paddle pretty soon. You see, if a man was in a little boat paddling, that is exactly the way his body would swing, from right to left."

"Yes, Stanworth, I think you're right, except that there isn't any boat. The searchlight's on the thing full tilt; and if there were a boat we'd see it."

"Yes," assented Stanworth, "that is what perplexes me; but

I think we shall have a solution of the mystery pretty soon. I see our boats are pulling for the thing, whatever it is."

I looked, and there were our two life-boats racing, with all the vim and precision that was in them, for the prize. One boat got a little ahead of the other, and soon we saw the white object lifted into one of the boats. Then both boats pulled for the ship.

The men were sent aft to man the life-boats' falls, and I sent word to Surgeon Lumsden that I thought we had picked up a man, and for him to be prepared to receive him in the sick-bay. Then I went aft on the quarterdeck. Both boats soon neared the ship; and in one of them was a man, in dark clothes, sitting in the stern sheets. I hailed the boat and asked if the man were badly hurt, and the man himself replied, "No sir, I'm all right."

By this time the surgeon had joined me on the quarterdeck and said:

"Before receiving the man in the sick-bay, sir, I should like to examine him, and see if he has any contagious or infectious disease."

"Very well, doctor, I'll have the man brought here, and you may examine him as you think best. I'll not interfere."

The boat was hoisted level with the deck, and the man was passed out, and carried forward by two stout sailors, and brought before the surgeon.

"Can you stand up?" said the surgeon.

"Yes, sir," said the man; and at a sign from me, the two men put him on his feet and let him stand up. He was a man of middle size, with a short brown beard; apparently about thirty-five years old. He had on a shirt and a pair of trousers.

"Have you any contagious or infectious disease?" said the surgeon.

"No, sir."

The doctor put his hand on his pulse and said, "Open your mouth." The man opened his mouth and it looked healthy, except that his tongue was swollen.

"How long have you been in the water?" said the surgeon.

"Nearly three days, sir."

"How long since you've had any food?"

"Just three days ago to-night, sir."

"How long since you've had any water?"

"Same time, sir."

"Do you feel any special pain or distress in any part of your body?"

"Well, I feel pretty tired, but I'm all right," was the sturdy reply.

He was carried below, and I will never forget the feeling of admiration with which I looked at this man, so calm and self-possessed after passing through such an ordeal. In my experience, I have never known his nerve to be equalled.

About an hour later the surgeon reported that the rescued man was now asleep, and that he thought that there was nothing the matter with him, except that the flesh of his arms and thighs was greatly lacerated.

The next day I went down to the sick-bay and found him lying in a cot. He put out his hand and said to me, in a cordial but matter-of-fact tone:

"I'm very much obliged to you for saving me, captain."

"I'm very glad to have saved you; we sailors have to do these things for each other, now and then."

Then, in reply to a question, he told me that his name was George Olsen, and that he had been first mate of the schooner *Twilight*, bound from Charleston to some northern port. On Monday they had been caught in the cyclone, but had managed to get some supper Monday night. About six o'clock Tuesday morning, the schooner had been thrown on her beam ends, so that her masts rested on the water. The masts almost immediately broke in two, and the schooner went bottom up. He, himself, was thrown out violently into the water, with a great deal of lumber with which the schooner was laden. This lumber was hurled about by the waves, and he thought that the other men were probably killed by the lumber at that time. He, however, managed to get clear of the wreckage. He then got hold of two boards, and supported himself by putting his arms over them. He had on a pair of thick rubber boots, a heavy oilskin coat and a souwester.

He remained in this position twenty-four hours. At the end of that time the violence of the sea had diminished. He then took the two boards and placed them in the form of a cross, and lashed them together at the cross with a sort of rope, made by tearing his oilskin coat into strips and tying them together. He then sat astride of this cross, and found a small piece of wood,

which he used as a paddle. While in this position, he saw the smoke of several steamers, but could not make the people on board see him. Finally, on Thursday night, he saw the white, green and red lights of a steamer coming towards him very fast. He paddled as hard as he could until he got directly in front of her; then, as she got very near, he paddled out just clear of her course, and yelled for help with all his might.

"And pretty soon," he said simply, "I saw the ship turn around, and then I knew I was all right."

I kept Olsen on board a month, until his flesh had healed. Then we got up a subscription in the ship, and he went home to his wife and family in Sweden.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

SOME COMMENTS ON EROSION AND BALLISTICS.

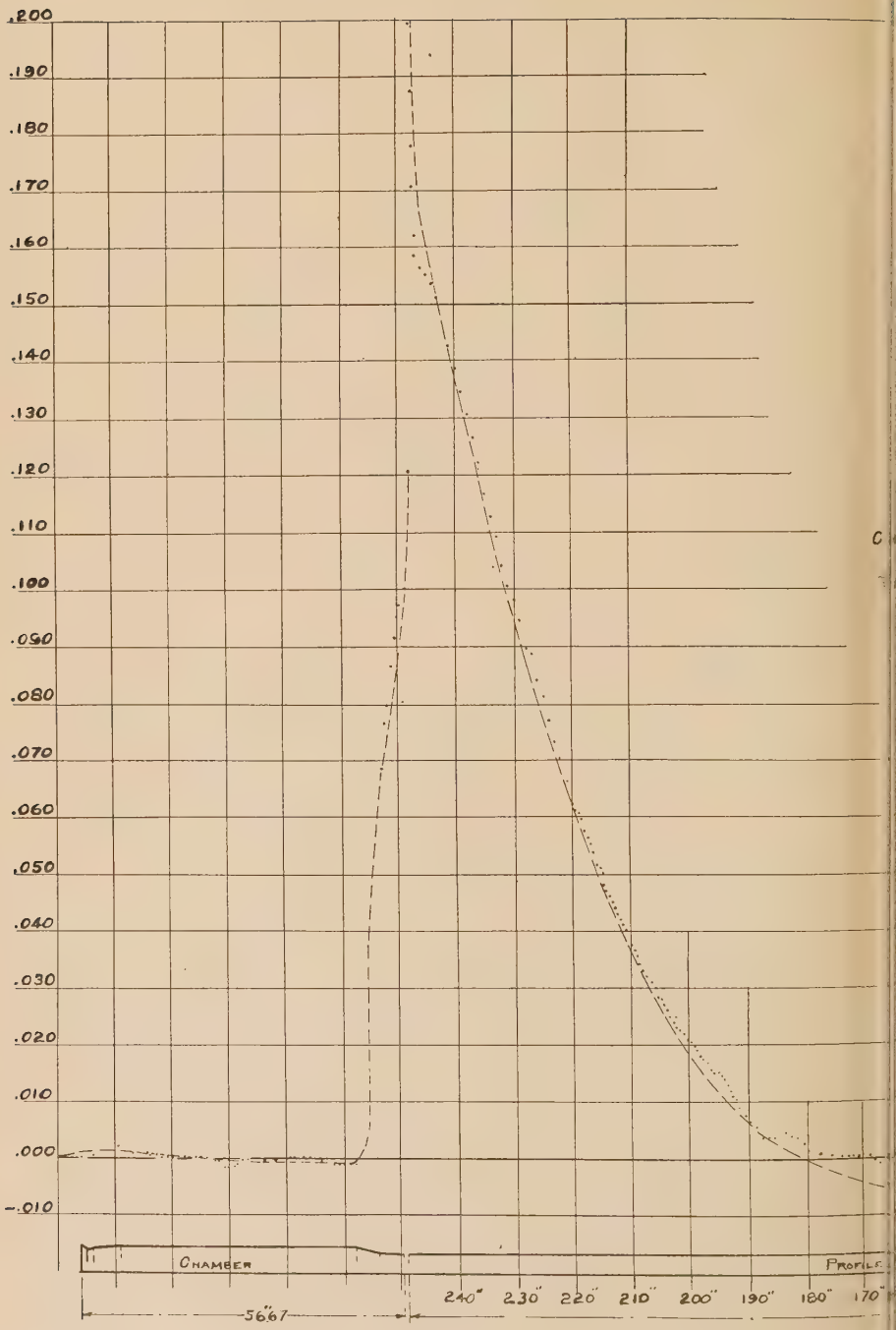
By Lieutenant-Commander H. E. Yarnell, U. S. Navy.

In an article on gun erosion in the Proceedings of the United States Naval Institute for September, 1910, the author, Professor Alger, advances numerous reasons to prove the fallacy of the theory of the cause of gun erosion which was advanced by the writer in an article on the same subject which appeared in the *Journal of the American Society of Naval Engineers* for May, 1910.

This theory is that "gun erosion is caused by the escape of the highly heated gases of combustion through the minute openings between the rotating bands and the bore of the gun before and shortly after the projectile begins to move."

In describing the character of erosion, Professor Alger states that "erosion as it occurs today in U. S. naval guns is a smooth wearing away of the bore beginning in rear of the rifling and extending further and further down the bore as the firing is continued," etc. In Fig. 1 is shown the curve of erosion as obtained in 7-inch gun No. 1 after firing 206 rounds. It will be noted that the erosion is greatest at or near the origin of the rifling and decreases rapidly from this point. This was a modern gun fired at practically the same velocity as the service velocity of this gun today and with the same kind of powder, so that the character of the erosion cannot be greatly different from that which is obtained from guns at the present time. In this gun there was no pitting or guttering which is caused by "windage and imperfect sealing of the bore," to quote from the extract given by Professor Alger from the English Official Treatise on Service Ordnance.

It will be noted from an inspection of this curve that the decrease in amount of the erosion is very rapid as the distance increases towards the muzzle from the origin of the rifling.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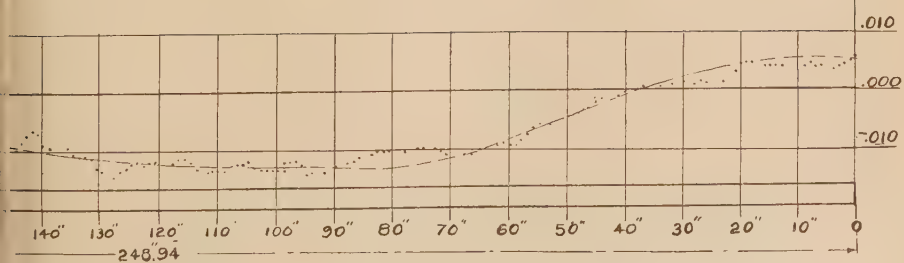

From a search of Professor Alger's article for a theory as to the cause of erosion the nearest that can be found is the statement that "the necessary and sufficient conditions for gun erosion are the intense heating of a thin film of metal at the surface of the bore and the *movement* of the gases over that surface."

That the above conditions are necessary to produce erosion was demonstrated by M. Vieille and the difference between the theory of M. Vieille and that of Professor Alger may be stated as follows: In the first case it is contended that the movement of the gases necessary to produce erosion is the movement due to the escape past the shell made possible by the imperfect sealing of the bore by the rotating band. In the theory as stated by Professor Alger, the movement of the gases takes place entirely in rear of the projectile.

What action really takes place in the gun from the time of ignition of the powder charge until the projectile leaves the gun is at present a matter of conjecture. The simplest condition to assume is that the powder charge remains in the powder chamber during combustion and that the bore of the gun is free from the partially burned powder grains. In this case the entire volume of gases will pass through the bore from the forward end of the powder chamber to the muzzle of the gun. The surface of the powder chamber is subjected to the heat of combustion during the entire time of combustion and discharge, while the bore is subjected to the heat for times varying from the entire period at the origin of the rifling to a time at the muzzle depending on the time of escape of the gases after the projectile has left the gun. In this case the powder chamber and bore of the gun are subjected to the same highest temperatures up to the point of maximum pressure although for varying lengths of time. From the point of maximum pressure to the muzzle the temperature falls gradually, although not to any great extent, since as stated by Professor Alger the difference of temperature as about 100 degrees Cent. for a difference of pressure of 7 tons at working pressures. The above condition is the most favorable to produce erosion according to the theory of Professor Alger.*

* Since the above was written my attention has been called by Professor Alger to the fact that the difference of temperatures at different pressures as stated by him applies only at the time of combustion, and not after work has been done on the projectile and the temperature of the gases

However, it is open to question whether such a condition actually exists. When a heap of nitro-cellulose powder composed of the short grains in use in our service is burned in the open air, there is a violent ebullition of the grains, some of them being carried from 15 to 20 feet in the air by the upward flow of the gases of combustion. It is probable that upon the ignition of the charge a similar action takes place in the gun, and that the increasing volume of powder chamber and bore in rear of the projectile is uniformly filled with burning grains. In the case of guns in which the powder charge is made up in more than one section, the ignition charges of black powder of the sections furthest from the breech probably assist in such a distribution of the grains since the ignition of the rear charge is well under way and the projectile probably started along the bore, before they are ignited.

If this distribution of the grains along the bore as the projectile advances actually takes place as seems most probable, only a fraction of the total gases of combustion will pass over the space in which the erosion is greatest, and instead of the point of greatest erosion being near the origin of rifling it would seem that it should be moved towards the muzzle to a point where the time of subjection to the highest temperature, the temperature itself, and the volume of gas will combine to cause the greatest amount of erosion.

The fact that the lands are worn about twice as much as the grooves is offered by Professor Alger as an objection to the theory that the erosion is caused by leakage past the rotating bands of the shell. The same argument may be brought to bear against the theory of its cause as stated by him, since with a clear bore the incandescent gas is able to erode the grooves as deeply as the lands, assuming that the direction of flow of the gases is in the direction of the bore. It is possible that there may be a whirling motion of the gases at right angles to the axis of the bore, but it cannot be of great moment as compared with the direct forward movement of the gases through the bore, otherwise it would be apparent from the form assumed by the gases upon leaving the gun.

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considerably decreased. This will bring the temperature at the muzzle considerably below the maximum temperature although not in direct proportion to the work done, as a higher temperature is probably maintained by dissociation of the gases of combustion.—H. E. Y.

As is well known, when charges of powder are burned in an enclosed bomb, there is no erosion although pressures as high as actual working pressures are attained, and the walls of the bomb are subjected to the same degree of heat as the walls of the powder chamber and bore of the actual gun. Hence it is clearly established that there must be a flow of gas over the heated surface at a certain velocity to produce erosion. What this velocity must be is not known. If the charge is distributed along the bore during combustion, as seems probable, the velocity of flow over the point of greatest erosion may be very small. I am not able to state what the velocity over this point would be if the charge burned in the powder chamber, but at most its velocity would be very small in comparison with the velocity of a gas at the same pressure escaping through an orifice to atmospheric pressure.

The small velocity which the gas can have when retained behind the projectile makes this case very similar to that of a closed bomb in which no erosion occurs.

One of the reasons advanced by Professor Alger against the theory that erosion is caused by the escape of gas past the rotating band of the projectile is that the rotating bands of fired projectiles do not show any signs of erosion. It is presumed that he means that they do not show any signs to the eye, as a copper band that has been subjected to the deforming influences of the rifling does not lend itself to very accurate measurement. The melting point of copper is about 1050 degrees Cent. which is not greatly below that of gun steels, so it is not surprising that a rotating band fired but once should not show any signs of erosion. It can be supposed that even if erosion of the band takes place to such an extent that it would be apparent, such evidence will be obliterated when the shell reaches the middle of the bore where no erosion takes place and where the diameter of the bore is smaller than that of the eroded section.

With regard to the latest form of rotating band it is undoubtedly true that it is a more efficient seal against the escape of gas than the older types. But are we justified in assuming that the "sealing is nearly perfect" and that leakage is negligible as far as erosion is concerned? The steam engineer has difficulty to obtain tight joints with steam pressures at about 300 pounds. An apparently sound casting may show leakage through the pores of the metal when subjected to a hydraulic pressure of 3000 or

4000 pounds. Can we then positively state that the rotating band offers a "nearly perfect seal" against the escape of a gas whose pressure is 40,000 pounds?

With regard to the statement that the conditions which existed at the time of the Vieille experiments were apparently different from those that exist at the present time, it will be noted that nitro-cellulose powder was in use in the French Navy at that time, and according to Clowes' Naval Pocket Book for 1901, the muzzle velocity of French ordnance was as high as 2624 f. s. As that is a higher muzzle velocity than obtains with the large caliber guns of some of our battleships in commission today, it is not believed that the conditions were greatly different at that time.

In all the problems connected with interior ballistics and the strength of guns, so little is known of what actually takes place in the bore of the gun from the time of ignition of the charge until the projectile leaves the gun, that no one can state positively that certain results are produced by certain causes. The whole action may be so complex and so many unknown factors may enter that perhaps if the truth were known the most important of the causes, not only of erosion, but of the other problems of ballistics, have not been touched.

At what pressure does the projectiles start to move?

During combustion, does the charge remain in the bore, or is it distributed along the bore?

What form does the pressure curve actually take?

At what point in the bore would the gas pressure upon a gauge change from a static to a dynamic action?

What effect does pressure have upon the rate of combustion of the powder?

What are the actual stresses to which the walls of a gun are subjected when fired?

The above are questions that await solution. The number of guns that have exploded in our service is sufficient proof that the mathematical formulas by which they were designed were defective in some vital respect.

Even in exterior ballistics whose problems are easier of solution than those relating to interior ballistics and the strength of guns, it was discovered at the target practices of the fleet that even at this late day the accepted formulas for the drift of projectiles were widely at variance with the actual results.

In this connection the writer stated in connection with the article on gun erosion in the *Journal of the Society of Naval Engineers* that the average muzzle velocity obtained with the Brown and Crozier wire wound guns was 3600 foot seconds, which as Professor Alger points out "goes considerably beyond the facts." When the above article was written, the writer depended on his memory for the above velocity and it seems that in this case, his memory was somewhat at fault. The object in referring to the tests of these guns was to prove that in the case of a well-designed gun, the strength was sufficient to enable a much higher velocity to be attained than was possible at the present time on account of erosion. Since it appears that although the mean velocity for the whole number of shots fired was in the neighborhood of 3300 or 3400 f. s. instead of 3600 f. s. the final ten rounds in each gun were fired with excessive charges, 3740 f. s. being obtained in one gun and 3860 f. s. in the other. It would appear from the above that the argument is amply sustained.

The following extract from an article entitled "The Strength of Guns and Cylinders" by C. A. M. Smith, B. Sc., which appeared in a recent number of *Engineering*, is of particular interest:

"It is difficult to provide data for the stresses which actually take place when a gun is fired. Sir Andrew Noble has pointed out that owing to the almost infinitesimal time the highest pressures act, many guns have withstood pressures that would undoubtedly cause their failure were such pressures of high duration. It is probably only possible to speculate concerning what actually does happen to the material under these pressures.

"At the moment of explosion the gases produce the pressures shown by the ordinary hoop stress theory. In addition, the action of the rifling—in giving rotation to the projectile—also causes a certain amount of torsional stress. Further, the gases are incandescent and the heating of the interior of the bore must cause enormous stress due to unequal expansion. When the material reaches the point of elastic failure, the load is immediately removed, and all experiments tend to show that the effect of this is to raise the elastic limit of the metal. It is possible to conceive before the gun actually bursts the metal has graded itself off into material which, at the inner surface of the gun, has been very much overstrained, and on the outside of the gun is a little beyond the elastic breakdown of the material."

As has been pointed out, the greatest erosion takes place at that part of the gun where the velocity of flow of gas in rear of the projectile is almost nil, yet it is clearly recognized that there must be a certain velocity of flow of gas over the heated surface to produce erosion. It is difficult to conceive of any action of the gases in rear of the projectile which will produce the greatest amount of erosion within the narrow limits shown so strikingly in the figure.

Argue as we may, pro and con, so much still remains unknown that it is but natural for some to accept the theory that is sustained by research and experiment, until it can be displaced by another theory whose arguments are more logically and convincingly demonstrated.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

EROSION AND BALLISTICS: A REJOINDER.

By Professor Philip R. Alger, U. S. Navy.

In the article just preceding this, certain objections are made to a theory of the cause of gun erosion set forth by the present writer in the last number of the Proceedings, and a number of questions are asked with the intention of illustrating our ignorance of what really happens when a gun is fired. Without pretending to answer all the questions completely and with certainty, I am led to attempt an answer to some of them because they are of great interest to all who are concerned with ordnance—one in particular regarding the cause of the bursting of guns of vital importance.

Taking up first the objection made to my theory of erosion (I call it *my* theory merely for brevity) on the ground that the charge is distributed along the bore as the projectile moves, so that more hot gas passes over a point well down the bore than over a point near the origin of the rifling where erosion is greatest. The fact that the pressure gauges put loosely in the bottom of the chamber of a gun are almost always found remaining there after the gun is fired lends some color to my view that the bulk of the powder charge also stays in the chamber. But independent of that, it is not necessary to assume that the movement of the gases rubs off the softened metal; it may merely be that motion of the gases over the surface is necessary to allow enough heat to be transmitted to the metal to melt it away. It is well known that the transfer of heat from a gas to a metallic surface is greatly assisted by movement of the gas, the reason being that a film of partially cooled gas adheres to the surface and impedes the conduction of heat; rapid motion of the gas tears this film away. Furthermore, it has been found that a large part of the heat transmitted by hot gas to a metal in contact with it comes from radiation,[1] and perhaps this ex-

[1] See a recent report of the Gaseous Explosions Committee of the British Association for the Advancement of Science.

plains why the quantity of heat as well as the temperature plays a large part in the heating of the gun wall. The bore at the origin of rifling is exposed to the radiation of heat from the powder gases longer than portions of the bore nearer the muzzle and so receives more heat than they do.

However all this may be, it seems to me quite certain that the ignition charges of the front sections of the powder charge cannot play any part in distributing the grains of powder along the bore. Since the projectile cannot move until there is enough pressure on its base to force its rotating band into the rifling (2 tons per square inch or more), not only must all the ignition powder have been inflamed but every grain of the charge must be burning fiercely before the projectile starts. The temperature in the powder chamber when the projectile begins to move must be in the neighborhood of 2000° C.

As for the argument that gases moving *behind* the projectile would erode grooves as much as lands—the explanation of the fact that they do not is simply that the lands, projecting into the hot gases, are more easily heated than are the bottoms of the grooves.

In considering the question of the efficiency of our present rotating bands in the matter of preventing the escape of gas, it must be remembered that the time of action is extremely small, so that the difficulty is much less than it would be if the pressure were a sustained one. It is true that we cannot "positively state that the rotating band offers a nearly perfect seal against the escape of a gas whose pressure is 40,000 pounds"; yet it is still my opinion that such is the case. If any gas does get through the close metal contact (nearly 4 inches long in a 12 inch gun), it must, I think, lose practically all its heat in doing so.

To answer the question at what pressure does the projectile start to move, we have the results of extensive experiments made at the Watertown arsenal and reported in various volumes of *Tests of Metals*. The actual force required to push a projectile through the bore was measured for guns from the small arm to the 12-inch rifle, and while it is probable that the quicker action, as well as the expansion of the bore by the powder pressure, will make the required force less in a fired gun, we certainly can feel sure of having its value in the latter case within reasonable limits. Roughly speaking, it takes about two tons per square inch to start a large caliber projectile,—more for the smaller calibers,—and the

force required to overcome the resistances of friction and forcing reduce to something less than one ton per square inch as the muzzle is approached.

As to the form of the pressure curve in a gun:—We know the maximum pressure by measurement with the crusher gauge, the reading of which should be increased about 8 per cent to allow for the fact that the coppers offer greater resistance to crushing in a gun than they do in a testing machine.[2] We know the pressure near the muzzle by measurement of the velocities given by the same charge in guns of different lengths. And we know the area under the pressure curve, since it must be equal to the total work of the powder charge in the gun. From these data we can certainly construct a pressure-space curve of reasonable accuracy.

The pressure action on a gauge in a gun does not change from static to dynamic at any *point in a gun;* it changes gradually from one to the other, being wholly static in the chamber and practically wholly dynamic near the muzzle where the time taken to expose the gauge to the action of the pressure is reduced to a few hundred-thousandths of a second.

Vieille's experiments have shown that ether-alcohol colloids of gun cotton, such as our smokeless powder, burn with a velocity proportional to about the two-thirds power of the pressure. Some writers on interior ballistics have attempted to discredit this value and have adopted unity as the exponent of the pressure, but the fact that their mathematical calculations are greatly facilitated by substituting one for two-thirds explains their preference for the former quantity. Here we have a real case of facts being forced to yield to theory.

In regard to the velocities used in the tests of the Crozier and Brown wire-wound 6-inch guns, I find that the actual average velocity of the 98 rounds fired was 3231 f. s. There were only 18 rounds at 3400 f. s. and above; 11 at 3500 f. s. and above; 7 at 3600 f. s. and above; 5 at 3700 f. s. and above; and 1 at over 3800 f. s. These are the true figures for the Crozier gun (those for the Brown gun are practically the same), and they fully justify my

[2] See appended translation of *The Influence of Velocity on the Law of Deformation of Metals, by P. Vieille and R. Liouville* (Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, May 14, 1906); also of *On a Method of Measuring the Resistance of Metals to Rapid Deformations,* by the same authors (Comptes Rendus, etc., Dec. 31, 1906).

original statement that 3600 f. s. was *considerably* greater than the average velocity.

We now come to the most important question requiring answer. Why, if we really know what the pressure is and if our theory of the strength of guns is correct, do our guns sometimes burst? This question I propose to answer at some length, first taking up a theory of the strength of guns and cylinders which, if accepted, would be a sufficient explanation of our gun accidents.

This theory, advanced by Professor C. A. M. Smith in an article in *Engineering*, is interesting, but fortunately can be disproved. It rests upon the assumption that what is known as Guest's law applies to gun steel. Guest's law, so called, is that failure occurs when the maximum shear stress at any point exceeds the resistance of the material to simple shear, this latter being one-half the resistance to simple tension. In designing our guns and calculating their strength we assume that failure will not occur until the maximum *strain* at some point exceeds the allowable strain in simple tension. Upon the first theory the strength of a gun is only about half what it is upon the second theory. That guns do not burst whenever they are fired is explained by Professor Smith as probably due to the short time of action of the pressure.

Now in the first place, in modern guns, the time during which the maximum pressure acts is very much greater than it was in the days of smooth bores and black powder. In our 12-inch 45-caliber gun, for instance, it takes a little more than one hundredth of a second for the pressure to rise from about 2 tons per square inch (when the projectile begins to move) to its maximum of say 17 tons per square inch, and about an equal time to decline to its muzzle value of 5 or 6 tons per square inch. This, in view of the enormous speed at which elastic vibrations are transmitted through steel, would seem ample to cause rupture, if the pressure applied really greatly exceeds the resistance of the gun.

In the second place, in such tests of thick cylinders as have been made within my knowledge, the interior pressure required to produce permanent expansion and that required to produce rupture have been fully equal to the pressures calculated by the maximum-strain theory as necessary to cause the metal to reach its elastic limit and tensile strength respectively.

For example, a 6″ gun jacket (17″.25 outside and 11″.75 inside diameter) tested to destruction, in 1901, at the Indian Head

U. S. Navy 12-inch, No. 16. Burst at Indian Head, February 9, 1906. Section of Tube Showing Heat Cracks at Bottoms of Grooves. Cracks *a* and *b* Produced when the Gun Burst.

Proving Ground, by exploding charges of smokeless powder within it, its ends being closed by heavy steel caps, stood pressures up to 7.5 tons per square inch before it showed any permanent enlargement and only burst under a pressure of 13.4 tons per square inch. The elastic limit of the steel in this jacket was about 22.5 tons and its tensile strength about 40 tons per square inch. According to Professor Smith's theory the elastic resistance of this jacket should have been reached with a pressure of about 5.5 tons and its ultimate strength with a pressure of about 10 tons. According to our maximum-strain theory the figures should have been 7.3 tons and 13.0 tons respectively. And again, a 5-inch gun jacket was tested with hydraulic pressure at the Watertown Arsenal in 1906. Its diameter inside was 5″.08 and outside 8″.15; its length 18″.5; pressure applied by forcing into it a piston of the same diameter as the bore, the other end being closed by a plug, so that the ends were free and there was no longitudinal stress. The first yield was at a pressure of 24,960 lbs. per square inch, when the tangential true stress (total strain times modulus of elasticity) was 65,000 lbs. per square inch; the greatest pressure applied was 30,720, giving a tangential true stress of 80,000, beyond which it was found impracticable to keep the hydraulic packings tight. According to Professor Smith's theory the elastic limit should have been reached at a pressure of 17,500 lbs. per square inch.

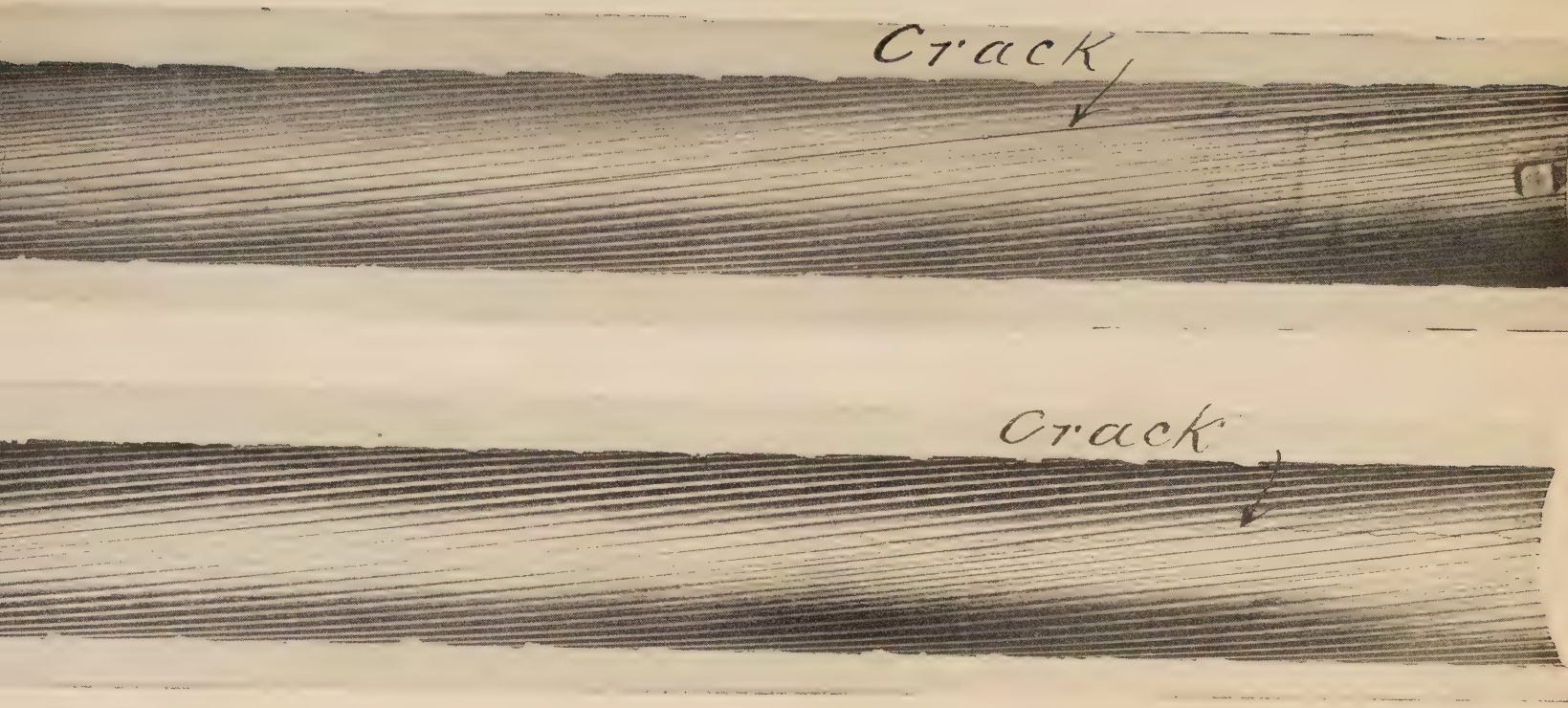
Finally, and I think conclusively, the bores of guns after repeated firing are found upon examination (after the jackets and hoops have been removed) to be in a state of circumferential *tension;* whereas, if the gun were overstrained by firing, the inner surface of its tube (when free from the compression of jackets and hoops) would be found to be in a state of circumferential *compression.* This may be demonstrated by trepanning from the bore of an old gun a thin ring of metal; if such a ring is cut through on an element, it will be found to close in on itself, not to open out. Or, if a section of such a gun tube be put in a lathe and turned down on the outside, its bore will be found to contract, the removal of the outer metal gradually freeing the inner metal from its state of tension and allowing it to shorten. If Professor Smith's idea were correct that " before the gun actually bursts the metal has graded itself off into material which, at the inner surface of the gun, has been very much overstrained, and on the outside

of the gun is a little beyond the elastic breakdown of the material," it is evident that the inner surface of the gun tube (when freed from the compression of jackets and hoop, and at rest) would be in a state of *compression* circumferentially and, if freed from the outer metal of the tube, would expand. *The fact that it contracts when so freed proves that the pressures to which it was subjected in firing have not overstrained it.*

The explanation of the actual state of tension of the bores of guns after use is supposed to be as follows: At each discharge the metal at the surface of the bore is heated to a temperature that would cause it, if free, to expand a great deal more than it can stretch within its elastic limit; its free expansion being prevented by the outer metal (which remains cool), it takes a permanent set in compression, or, in other words, is crushed; then, when it cools, it is held in a state of tension by the outer metal.[3] (Or, in the case of a built up gun, it is less compressed than it was.) The result is that the surface of the bore more and more assumes a state of circumferential tension, and ends by developing longitudinal cracks (which we call heat cracks). These cracks appear at the bottoms of the grooves of the rifling (at the roots of the driving edges of the lands when the grooves are hook shaped and at both corners of square sectioned grooves), and they work further and further into the metal as the use of the gun continues, finally becoming deep enough to seriously reduce the strength of the gun. Thus, for example, a ring cut from the tube of an army 12-inch gun without boring to remove the rifling burst with no stretch under a hydraulic pressure less than half that which another ring adjoining the first (but bored out) stood,—the second ring stretching 11.5 per cent without rupturing. And, again, army 8-inch B. L. R. No. 1, after firing 388 rounds, was taken apart for examination and it was then found that its tube was cracked through in two places and that the chase hoops, which alone prevented the gun's bursting, were stained on the inside with powder gases that escaped through the cracks each time the gun was fired.

[3] This action can perhaps be made clear by the following illustration. If a block of metal, say a short cylinder, is fitted tightly between two immovable plates and then heated, it will be found, when cooled again, to fit loosely, so that it will be necessary to stretch it to restore its original length; being unable to expand when heated, it has crushed itself.

The heat expansion corresponding to 250° F. is about equal to the extension of gun steel at its elastic limit.



U. S. Army 8-inch, No. 1, after 388 Rounds. Right and Left Halves of Tube Showing Through Cracks.

This is the answer to the question why certain of our guns have burst along the chase. The strength of these guns as designed and built, even though they were not hooped to the muzzle, was ample to resist the pressures developed by the normal action of the powder charge. When the first one burst there was a choice of two theories to explain it,—either the powder or the gun was at fault. As the metal when tested proved good, the blame was laid on the powder, which was thought to have burned abnormally and given rise to an excessive pressure at the muzzle. Other guns burst and in no case did the metal of the gun show any sign of being defective. Then it was noted that there had been a tendency to make powder slower, so that very large charges were being used to give the standard velocity, and it was thought that the result might be higher muzzle pressures than the guns could stand. But tests at the proving ground showed that even with the slowest powders the muzzle pressures were within the calculated elastic strength of the guns. Of course the theory that guns are weakened by crystallization of the metal due to the shock and vibration of repeated firings was not overlooked, but no reasonable justification could be found for such a far fetched theory.[4]

Finally, some two years ago, the existence of heat cracks in guns was discovered at the Watertown Arsenal,[5] and all was explained. Guns are weakened by continued use, though the metal itself is not altered,—a factor of safety quite sufficient when the gun is new ceases to be so after the gun has become old. Hooping all the way to the muzzle is necessary to provide sufficient strength

[4] In 1883, or thereabouts, when Captain Sicard, then Chief of the Bureau of Ordnance, proposed to build wire-wound guns for the Navy, a test of this theory was made at the Washington Navy Yard as follows:

Heavy weights, sufficient to strain the wire nearly to its elastic limit, were suspended by pieces of the wire intended for use on the guns, and small hammers were arranged so that, actuated by the machinery of the shop, they struck the taut wires at regular and frequent intervals. After months of constant vibration, all the time under severe strain, the wires, when tested, showed unchanged physical qualities. Moreover, every gun, army and navy, that has suffered accident, since we first began to build steel guns, has had the metal of the part that failed tested, and never has there been a case when any material difference was found between the physical qualities shown by the last tests and those shown by the original tests for acceptance. One of these guns, a 12-inch, had been fired 481 rounds when its muzzle was blown off.

[5] For a very complete and interesting study of the metal of the tube of an army 12-inch gun that burst in 1907, see *"Tests of Metal, 1908."*

even after the tube has been weakened by the development of heat cracks. The advantage of having an inner tube or liner, before not seen, became apparent, its effect being to limit the extension of cracks and thus to prevent the actual bursting of the gun even in the event of a high pressure causing a crack to extend through the liner.

In corroboration of this statement, see the Report of the Chief of Ordnance, U. S. Army, 1909, in which General Crozier says: "During the past few years the department has not been free from the occasional failures of heavy guns, which are believed to have been met with in all services, under powder pressures below those corresponding to the elastic strength of the pieces. A thorough study of the guns that failed and the experience of the department in connection with the manufacture of forgings and their assembling into built up guns indicate conclusively that the trouble arises not from defect in the design of the cannon, but from either concealed defects in the forgings or the development of thermal or heat cracks. . . . . These cracks are due to the high temperature of the powder gases, and increase in depth and number as the number of rounds fired increases, though the increase is more rapid in some guns than in others fired under the same conditions. . . . . To the prevalence of these cracks and the accompanying brittle condition of the metal of the surface of the bore, the department attaches great importance, and has decided to reline guns as soon as these thermal cracks become very pronounced, instead of waiting until the accuracy life of the gun has been reached, due to erosion and wear. All seacoast guns of 6-inch caliber and over, except mortars, manufactured hereafter will be provided with double tubes, so that if, from defective material or thermal cracks, the inner tube gives way, the damage will not extend to the outer tube and the enveloping jacket and hoops."

A recent article in *Engineering* puts the blame for accidents to our guns on the form of powder grain that we use, the multiperforated cylinder, but the powder has nothing to do with it, excepting to the extent that we give our guns harder usage than any other navy. The twenty rounds, all full charges, that we fire annually from each 12-inch gun is much more, I believe, than any other navy fires.* Unfortunately it is the gun itself that is at fault,

* The total allowance for large caliber guns in the British Navy is 16 rounds a year, of which some, and probably the greater part, are reduced charges.

U. S. Army 8-inch, No. 1, after 388 Rounds. Interior of Chase Hoops Showing Escape of Gas Through Crack in Tube of Gun.

and the only remedy so far as yet known is to construct guns having a greater factor of safety along the chase than our earlier models and to reline all guns after they have fired a certain number of rounds.

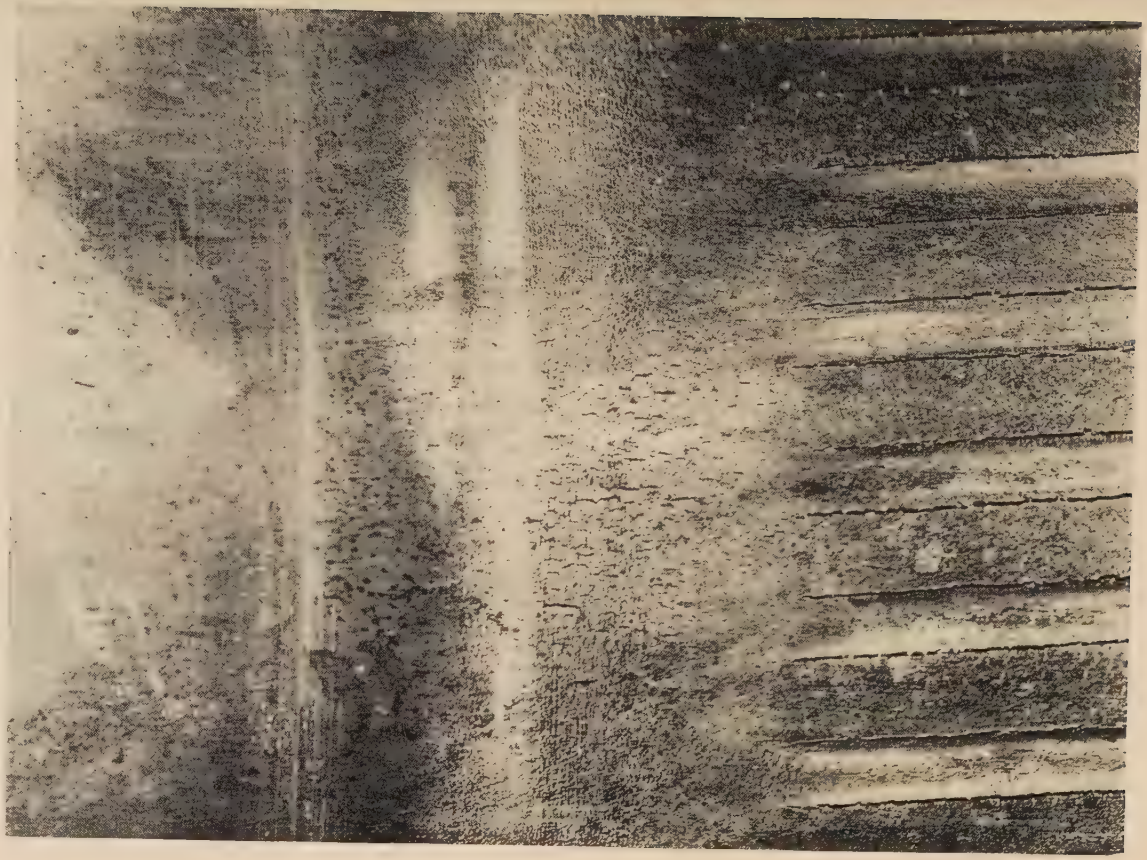
A final point in regard to which it is said that theory does not agree with practice is the drift of projectiles. Now when theory seems at variance with facts it must not be overlooked that an error in the facts, or a misinterpretation of them, will explain the discrepancy just as well as an error in the theory. Too often a correct theory is condemned because it does not accord with alleged facts that really are not facts. Moreover, facts in themselves are of little value; it is the conclusions that are drawn from them that are, or may be, valuable, and errors of reasoning are just as likely to creep in here as at an earlier stage.

In this particular case, observations of drift made on certain ships, one in particular, gave results greatly different from those calculated by the well known Gâvre formula ($D=KV^2 \sin^2 a$) using a particular value of the constant ($K=.0025$), and it was concluded that the formula was wrong,—not that the value of the constant was wrong, which may very well be true, but that the formula was wrong. On other ships the measured drifts agreed very closely with their calculated values, and that alone should be sufficient to prevent condemning the formula until less doubtful facts could be brought against it. But independent of this, experience shows that drift at long ranges is so greatly affected by conditions which escape observation (such as wind, which may be quite different at an altitude from what it is at the sea level), that the determination of it by a few rounds on one occasion is of no value. As a matter of fact, after years of experiment at Indian Head, we are unable to give anything but a very rough approximate value to the drift. After examining all the records and testing various formulæ with them, I am of opinion that the Gâvre formula is about as good as any other, though the value of the constant seems to be somewhat less than stated in my Exterior Ballistics (about .0016 for the old form of projectile and somewhat more for the new form). The formula $D=kX \sin a$ ($D=$drift; $X=$range; $a=$angle of departure; $k=$constant), recently proposed by Lieut. P. Bertagna, Italian Navy (*Revista Marittima*, Oct., 1909), is perhaps a little better than the Gâvre formula for high velocity guns; the formulæ of Mayevski, Charbonnier and

Hamilton are much less simple and no more accurate as far as can be judged from our experimental results.

In conclusion, and returning to the subject of erosion, I have recently learned of experimental results that confirm my belief that measurements of the erosion produced by the escape of powder gas through vents are inconclusive as regards real gun-erosion. Sir Andrew Noble recently stated, in a paper read before the North East Coast Institution of Engineers and Ship-Builders, that the British officially promulgated statement that it takes 4 three-quarter, or 16 half charges to produce as much erosion as one full charge is wholly incorrect. His bomb experiments had shown "that the erosion due to 1 three-quarter charge was less than that of a full charge, but that 2 three-quarter charges gave more erosion than 1 full charge; while 2 half charges gave less, but 3 half charges gave more erosion than 1 full charge; or, in other words, that the erosion was a little less than that due to the comparative weight of the charge."

Here is a case where the facts are correct but are misinterpreted,—instead of assuming that his experiments disproved the statement about relative erosions in guns, which in fact is substantially correct, Sir Andrew should have seen that they merely proved the inapplicability of his method of measuring gun erosion.



U. S. Army 5-inch. Origin of Rifling, Enlarged. Showing Heat Cracks at Both Corners of Square Sectioned Grooves.

THE INFLUENCE OF VELOCITY ON THE LAW OF DEFORMATION OF METALS.[6]

By P. VIEILLE and R. LIOUVILLE.

Translated by Prof. Philip R. Alger, U. S. Navy.

To measure pressures in guns, gauges are used in which a light piston is acted on at one end by the rapidly changing pressures that it is proposed to evaluate and at the other end by a small copper cylinder, the resistance to crushing of which balances the acting pressure at each instant.

The masses put in motion are sufficiently small for the forces of inertia, which moreover can be measured by registering the movement, to be entirely neglected. Under usual conditions these forces are less than one-thousandth of the pressures to be measured.

Precision of measurement therefore depends solely upon the correct evaluation of the resistances opposed by the cylinder, for each value of its shortening, under the actual conditions of ballistic use. In the absence of this special law, a law of static resistance is easily obtained by experiments (called *tarage*) in which the cylinder is crushed at very small speed, a few tenths of a millimeter per second, corresponding to a rate of increase of pressure of a few hundred kilograms per second, while under ballistic conditions the cylinder is crushed at speeds from one to ten thousand times greater, that is of the order of the meter per second.

For many years experimenters have devoted themselves to the study of the modifications that velocity could introduce into the law of static resistance given by tarage experiments. Among the labors carried on in France, it will suffice to recall the investigations of M. Charpy and of MM. Galy-Aché and Charbonnier. One point of great importance has been put beyond doubt by MM. Galy-Aché and Charbonnier: a cylinder subjected to a rapid crushing process possesses, after its temperature has returned to the original value, a higher resistance than that of a cylinder brought by a slow action to the same form and the same final compression.

This observation establishes beyond question an influence of

[6] Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, May 14, 1906.

speed; it implies, furthermore, for the expression of the law of resistance of the crusher, a consequence that does not seem to have been perceived. There results from it in fact that no function of the amount of crushing e and of the speed of that crushing e' can serve to represent the resistance R; dR, expressed in terms of de and de', cannot be an exact differential.

The influence of velocities upon the resistance should be principally considered in two classes of ballistic applications; the measure of maximum, or final pressures, and the law of development of pressures.

In the first application, the final resistance is obtained under a zero speed of crushing. In the second, it is the resistance of the cylinder at the velocity of crushing which must be known at each instant.

As regards maximum pressures, old experiments have shown that the real pressures are given with close approximation by the manometric tarage table.* To pass from tabular to absolute values, MM. Galy-Aché and Charbonnier proposed a correction of about 5.5 per cent. A modification of this nature is of no material consequence in researches in which the maximum pressures alone are under consideration.

On the contrary there was a great uncertainty regarding the change of the law of development of pressures. The authors considered the correction applicable to the final pressures as the residue of much more important modifications, doubtless greater than 20 per cent, that it would be necessary to apply to the tarage pressures corresponding to the traces in order to derive from them the real resistances at each instant.

We have sought to obtain a direct evaluation of these resistances by a method of opposition applied under the actual conditions of ballistic functioning.

The new data thus obtained, together with all those known from previous experiments, lead to a general expression for dR in terms of de and de' that takes account with sufficient accuracy of the peculiarities observed in the ballistic use of crusher gauges. The exposé of these results will be the subject of a further communication.

* This is practically the same as the tarage tables we use.—P. R. A.

ON A METHOD OF MEASURING THE RESISTANCE OF METALS TO RAPID DEFORMATIONS.[7]

By P. Vieille and R. Liouville.

Translated by Prof. Philip R. Alger, U. S. Navy.

In the study of the resistances offered by metals and notably by copper to considerable and rapid deformations, methods that utilize the pressures produced by ballistic explosives have special advantages to which we alluded in a preceding note.

In fact, by means of pressures developed by an explosive, we can determine the crushing of small metal cylinders (crusher discs) by means of pistons of mass so small that at each instant the forces of inertia are negligible, even when the initial height of the cylinders is reduced nearly one-half with velocities approaching 2 meters per second.

If two copper cylinders, separated by a light steel piston, are submitted to actions of this nature, it is easy to still make sure that the law of crushing is not changed by these additional masses. It suffices to inscribe on a turning cylinder the displacements of the piston acted on by the gas and of that which separates the two crusher discs. The first trace has its ordinates double those of the second; the forces of inertia, though notably increased for one of the pistons, have remained insensible.

If, in the preceding arrangement, one of the new cylinders is replaced by a cylinder already crushed without velocity, the origins of the two traces no longer correspond to the same instant of time, the first movement of the intermediate piston not taking place until the moment when the pressure transmitted by the cylinder that is being crushed exceeds the resistance of the auxiliary cylinder. The traces give, for this moment, the shortening of the first cylinder and the corresponding speed. Comparison with the initial height of the auxiliary cylinder makes known the difference of shortenings corresponding to a certain pressure, given by the table of tarage without velocity. This evaluation

[7] Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Dec. 31, 1906.

takes account of the thermic phenomena that accompany and are inseparable from deformation of the cylinder. Finally, a complete reading of the traces informs us what has been the law of the successive velocities of crushing realized by the cylinders.

We have made more than 60 determinations of this nature, with regulation naval crusher discs, at velocities of crushing from 1/10 to 2 meters per second, that is under pressures developing at rates of from 50 to 1000 tons per second.

Precision of measurement requires solely the correct determination of the point where the two cylinders begin to crush together. A special circumstance renders this measurement very precise. The curve of crushing, properly so called, of the second cylinder, instead of starting from a somewhat thick origin line, is preceded by a curve representing a very slight yielding of the system and upon which the desired point determines itself with great exactitude.

The results of the trials are collected in the following table:

No. of Tests.	Shortening of the moving cyl. at the instant the auxiliary cyl. begins to shorten.	Corresponding speed of crushing. (Mean value).	Difference of shortening of the two cyl.	Tarage Table Pres.	True pressure.
	mm.	*cm.*	*mm.*	*kg.*	*kg.*
8	0.99	42 : (6 to 100)	.01 to .05	857	863 to 887
8	1.80	60 : (12 to 124)	.20	1303	1403 (+7.67%)
28	2.64	69 : (13 to 144)	.36	1691	1839 (+8.75%)
13	3.51	81 : (15 to 170)	.49	2057	2262 (+10. %)
4	5.42	52.5	.37	2939	3140 (+6.84%)

These figures give rise to the following observations:

1st. The difference of the shortenings obtained with and without velocity, equal to a few hundredths of a millimeter for pressures of about 900 kilograms per square centimeter, rises to half a millimeter for pressures of 2000 kilograms, then decreases and falls to 0.37 mm. for a pressure of about 3000 kilograms.

The velocities indicated for each value of the shortening were taken from curves of different shapes obtained by making vary either the density of charge or the quickness of the explosive. In all cases the differences of shortenings, even the most considerable, were not influenced in a perceptible manner by the law of crushing chosen.

For example, under crushings of 2.65 mm., corresponding to pressures of 1700 kilograms, the differences of shortenings with and without velocity was found to be

0.38 mm. for a vel. of 1.44 m. s.
0.36 " " " 0.51 " } means of 4 trials.
0.35 " " " 0.17 "

the final shortening being 3.5 mm. and the maximum pressure about 2000 kilograms.

It was found to be

0.34 mm. for a vel. of 0.93 m. s., mean of 4 trials
.37 " " " 0.75 " " 8 "
.32 " " " 0.27 " " 4 "

the final shortening being 5.6 mm. and the maximum pressure from 2700 to 3000 kilograms.

These numbers correspond to a correction of 150 kilograms on the manometric table, with individual variations negligible in comparison with the principal correction.

Likewise, under shortenings of 4.5 mm., that is under pressures of about 2500 kilograms, the differences obtained in traces where the final shortening reached 6.0 mm., were

0.51 mm. for a vel. of 1.35 m. s.
0.44 " " " 0.34 " } means of 4 trials.

To sum up, in our tests, the effect of a change of velocities in the ratio of 1 to 10, the effect of a change in the laws of crushing within the limits attainable by us, remained inappreciable, and yet the absolute value of the correction applicable to the tarage table is notable, increasing rapidly with shortenings greater than 1 mm., and having a mean value of 8 per cent up to the limits of ballistic applications.

These determinations are not in disaccord with the ideas we have presented in a previous note, implying in principle the dependence of the final shortening and the law followed in reaching it. It should in fact be remarked that the traces given by explosives satisfy the common condition of being made, from the smallest crushings, under velocities of the order of the decimeter, that is a thousand times greater than the velocity of tarage.

2d. Examination of the curves brings to view another phe-

nomenon; after a small common travel, of about 1 mm., the two cylinders are brought to the same shortening and, from that instant, oppose always equal resistances to the pressures that are applied to them.

3d. On the contrary, if the complementary shortening of the auxiliary cylinder is limited to a few hundredths, or even a tenth of a milimeter, the initial difference subsists nearly wholly, whence results a second method of a comparison of resistances, with and without velocity, not requiring the registering of traces.

THE GENIUS OF NAVAL WARFARE.

II.

TACTICS.

By René Daveluy, Commander, French Navy.

Translated by Philip R. Alger, U. S. Navy.

VIII.

The Battle.

Let us first evoke the spectacle of a single-ship combat. The two vessels advance towards each other. When they come within range, they open fire.

At first the fire is slow, each side feeling for the target. Shell fall all around the ships. As they present themselves bows on, and the distance is changing rapidly, accuracy of fire is not to be counted upon.

At this moment the commander still remains master of his ship and his men; the gunnery officer really controls his guns; the divisional officers have their men in hand. There has been no faltering and the established conditions of battle quarters still subsist. The attitude of each one is all that reveals the difference.

The officers struggle to keep cool. They give orders slowly, but their voices are a little husky. The non-commissioned officers put a good face on the matter; accustomed to the critical situations of sea-life, they have confidence in their superiors and keep up the spirits of the men by those brief and figurative phrases that are characteristic of seamen. The sailors are pale; their faces betray their distress of mind; their eyes turn alternately from the enemy ship to their officers. Brutally recalled to reality by orders, they obey mechanically; their bodies move as if automatically, through force of habit.

In the depths of the ship a great excitement reigns. The machinists call loudly to overmatch the noise of the engines; the firemen nervously throw shovelfuls of coal onto the grate bars—the effort soothes them.

This situation lasts but an instant. Very soon the vessels arrive at deadly range and present their broadsides to give a clear field

of fire to their whole batteries. Then the tempest is loosed. All the guns fire; all the shots hit. The shell beat upon the armored sides like hail upon a window pane, terrifying the men in the coal bunkers, who imagine the ship will be smashed in. The superstructures are cut to pieces; fragments of the thin plating fly in all directions, wounding men in their way; mangled corpses encumber the passages; men paralyzed by fear cower in corners, death in their eyes, with halting breath. In the casemates, in the turrets, the excitement of firing rages. The gun servants uselessly accelerate their motions in order to forget themselves; the officers and petty officers with difficulty succeed in preventing the gun captains from firing wildly, with eyes shut.

On deck the confusion is extreme. The noise of the guns drowns all else. It is no longer possible to give an order; the means of communication are cut off, some by injuries, others by the uproar. The commander, who at first shut himself up in the conning-tower, has been obliged to come out to see better; powerless to make himself heard, he no longer directs his ship except by vague gestures that the navigating officer interprets as well as he can and transmits in the same manner to the helmsman. The vessel no longer obeys but by spasmodic movements.

In the midst of this unchaining of all the elements injuries multiply, guns are dismounted, compartments are flooded with water. The end is approaching.

Then the advantage will be seen clearly revealed in favor of the vessel that was able first to secure superiority of fire. For the third time, the aspect of the battle will change.

On one side, the commander, despairing of success, will begin to hesitate; he will think of saving the remnants of his fortune; the control will become uncertain; the battery, precipitating its fire to recover the advantage, will throw away its ammunition; the officers will be powerless to direct their men.

On the other side, the spectacle will be quite different. At the beginning of the action, courage is only sustained by an effort of will which takes away from each a portion of his faculties; but as soon as it is felt that the enemy begins to yield, the tension slackens; confidence succeeds to apprehension. Each one recovers his coolness and the battle then becomes more methodical. Like a man who struggles violently when he falls unexpectedly into the water and then swims slowly when he has recovered his senses,

each gun captain, after having fired wildly to protect himself, will fire only with the greatest precision as soon as he feels himself master of the situation. Every one will regain his balance; thenceforth victory is assured.

Let us now picture the fleet action in its simplest form; two naval forces engaged in two parallel lines, each vessel taking for its target a vessel of the opposite line. This is not a gratuitous supposition; history furnishes numerous examples of the sort.

It seems, then, that the fleet action must be made up of a series of individual actions, and that success will not be on the same side everywhere. Victor at one point, one may be vanquished at another, because in a numerous force all ships are not of the same value and do not always find themselves opposed to an adversary of the same strength. The victor ought therefore to be, in the final reckoning, the one who has had the fewest losses.

Very well! it is not so that things happen. It is the vanquished alone who loses or abandons ships; and those of the victor have usually suffered the least.

Is this because there is always a great difference between the combatants, both in respect to material and to personnel? Not at all; the victor of one day has been seen to be the vanquished of the morrow.

The real reason is that there is a common bond that unites all the ships of any one naval force. When this bond comes to be broken, it is impossible to reconnect the severed ends. If in an action a first advantage is secured at one of the extremities of the battlefield, the effect is immediately felt throughout the whole line. Victory, starting from a single point, will propagate itself everywhere, reanimating courage on one side and making the other side lose all that it had gained. As soon as the vessels of a squadron perceive any weakening on their own side, they no longer fight with the same ardor; they feel that their situation is compromised. Their adversaries, on the contrary, know that they will soon receive aid and nothing can make them give in.

Sometimes a badly executed maneuver, causing a partial stoppage, has been sufficient to bring about rupture of the balance of forces. One or two ships that become available join their efforts to those of their neighbors and an irresistible pressure is produced. Then at a corner of the battlefield the vantage is acquired

on one side, lost on the other, and nothing more is needed to decide the fate of the day.

If we now picture to ourselves an action between two fleets in which no attempt is made to oppose line to line, ship to ship; if, in the case of these two forces, the initial breach is determined, no longer by some incident, but by a tactical maneuver that annihilates with a single blow the resistance at a point; if, moreover, this point is judiciously chosen, then the victory will be more prompt and less costly.

The problem set for each ship is, therefore, to reduce the immediate adversary in the shortest time in order to assist friends and to destroy the efficacy of renewed attacks.

Theoretically, the best solution consists in sinking ships by aiming at their water-lines with armor-piercing shell. This is a method that has long been looked upon with favor; for the preponderance assigned for a long time past to heavy over medium calibers, and at the precise epoch when the guns were not protected, can only be explained by desire to reach the vitals. This preponderance even became a monopoly on a whole class of vessels that have only one or two big guns.[86]

The conception of firing with a view to sinking is attractive; it is also the most difficult to realize. The water-line, being the most sensitive part of a vessel, is the best protected. To attack it is like making a frontal attack upon a position.

Those who have advocated this method have confused the proving ground with the battlefield. To hit a strip 30 centimeters high there is necessary an accuracy of fire that requires mathematical data; the pointer must be unaffected by the excitement of battle; the target must be stationary. Moreover 50-ton guns are not assimilable to small arms, and the dimensions of the target should be in proportion to the ballistic accuracy of the guns; so that the chances of hitting the water-line depend upon the number of rounds fired, and as loading is slower in proportion as guns are bigger, time is necessary, and a very long time, to secure a hit.

[86] By a singular anomaly, while the whole power of a vessel was concentrated in two big guns, their operation was put at the mercy of a 14 cm. or 10 cm. projectile. In this respect the earlier coast-defence ships of *Tonnerre* type were more logical than the later ones, since their guns were in closed turrets.

This entire aggregate of operations would not offer any difficulty if the enemy were merely a motionless and passive target, but he is not so at all. Far from accepting blows without returning them, he will defend himself energetically; and while we are lingering over the execution of an accurate fire seeking the fault in his armor, he will bombard us full in the side and will dismount our guns. The first thing to do, therefore, is to extinguish his fire.

It is true that with the exception of the coast-defence vessels that form an important part of our naval strength, our armored ships have guns of medium and small caliber. It was to utilize them that the theory of the division of labor was brought forward.

To secure the maximum efficiency, we are told, each gun must fulfil the rôle that is most favorable to its utilization, relatively to the work that it is capable of accomplishing. Consequently the heavy guns, which are powerful, will devote themselves to firing against armor; the medium will destroy the unarmored parts and the small will attack the personnel.

The argument is a specious one. Not that the principle of the division of labor is false, but that it is only sound when applicable. But is it so in the present case?

What we wish is to wrest from the enemy the weapon with which he is destroying us. When we have succeeded in doing this, he will be nothing but a floating wreck that a torpedo, a shell fired point blank or a blow with the ram will finish. We are, therefore, abandoning our objective when we assign to the heavy guns a rôle that is disconnected with the end to be attained, and the return that they could render us will be the more missed the more sparingly medium guns have been distributed upon our fighting ships. By pursuing two or three objectives at once we risk not attaining any; it is true that we are sacrificing to the sacred principle of the division of labor, but it is at the expense of our interests. Is not this same principle satisfied equally well by disarming the enemy first, and then sinking or capturing him? Perhaps it is less mathematical, but it is more military.

By assigning to the slowest-firing guns a target that has the width of a geometrical line, we lose the greater part of the projectiles and the return is very small; so that, of the principle of the division of labor, only the skeleton is left.

Firing to cause sinking is a manifestation of the influence of

ancient ways. In the period of sailing ships the French persisted in firing at the masts and rigging; to-day they wish to hit the water-line. Thus we have substituted a horizontal for a vertical line; in both cases we have taken the most difficult course. The English, for their part, have always fired full at the hull, and they have come out well in doing so. Why do we persist in a system that has always given disappointing results?

We will, therefore, employ all our means to extinguish first of all the enemy's fire, to disarm him. And then the whole importance of rapidity of fire will make itself felt.

The advantages of rapidity of gun-fire have been contested for a long time. Yet it seems evident that a greater rapidity of fire is equivalent to a proportionate increase in number of guns, and that the superiority will be accentuated in proportion as the effect of the fire makes itself felt. The opponents of rapid fire do not deny these advantages; but they fear a squandering of ammunition that would empty the magazines in a short time and leave the ship without defence. This apprehension is justified on condition that at the time when ammunition is found wanting the enemy still has guns to fire; otherwise the shell that remain in his magazines will be of no use to him.

Rapidity of fire is an element of *strength* and also of *danger*. We should not deprive ourselves of the strength in order to avoid the danger, but should seek another solution that will allow keeping the strength and escaping the danger.

There are several means of diminishing waste of ammunition. The first is not to begin firing until within good range and to approach so near that all the shot will hit the target; a second is to have good fire-control; finally, a third is to increase the allowance per gun, and to replace with ammunition the dead weight of those absurd structures that tower aloft on our ships and recall a period when artillery did not yet exist.[87]

The power of his gun-fire is the chief reliance of a commander; it alone is capable of furnishing the immense number of projectiles

[87] The question of ammunition supply is one of the most acute to which modern material has given rise. Everyone understands the critical situation in which a naval force would find itself when lacking ammunition on the battlefield; but there is not enough weight given to the moral effect that an insufficient supply will have on the mind of the commander, who will be led at the very outset to make unfortunate decisions. (Witness the return of Bazaine to Metz.)

reaching the mark that will be required to extinguish the enemy's fire.[88] It will not be necessary, however, to disable, one by one, all the guns and all the fire-control stations of a vessel to render it powerless; under the hail of iron that will beat upon it, the hits that enter the ports will multiply; and, without the fatal hit that, perforating the armor, will definitely put a gun out of action, a quantity of accessory mechanisms will cease to work. A wheel out of gear, a port obstructed by fragments of plating, an ammunition hoist damaged, a line of sight blocked, a mechanism broken, all such injuries, some of which are unimportant, will only stop the fire for an instant, and will suffice to cause a momentary let up. To the material damages will be added wounds of the personnel. There will then be produced a slackening, a respite of a few instants, a fleeting occasion which will at once be seized upon to employ one's utmost means. A still nearer approach will be made with a view to point-blank fire at the water-line; a torpedo-boat will be sent to the assault, if one is near at hand; the torpedo itself will be tried, if the dilapidation of the hull indicates that the sighting stations are destroyed; finally there will be the supreme resource of the ram, if the occasion is favorable.

Usually it will not be necessary to go to that extremity. It is readily believed that the battle will last as long as the ship floats, as long as there remains a projectile on board, a gun to fire it and men to work the gun. But this takes small account of the physical exhaustion of the crew, of their state of enervation; it neglects the moral side, which is so important on the battlefield that it may be said that gun-fire produces more effect by its intensity than by its precision. Examine closely the most desperate encounters, and particularly that of the *Cochrane* and the *Huascar*. In reading these accounts are we not impressed by the fact that, in the midst of the action, the gunners cannot be expected to point with the precision that would be required in order to select their targets; they will be unable to do anything more than fire into the mass. The best pointers will be in a position like that of apt scholars who, when undergoing an examination, have their faculties diminished; and all that can be said is

[88] At the end of a few minutes the pointer of a rapid-fire gun will have his vision obscured; he will see through a mist. Each gun ought, therefore, to have several pointers who can succeed each other without causing delay.

that the good pointers, although firing badly, will fire better than the others. At all events it is an undeniable fact that in a battle the end always comes before the vanquished has used up his means of defence or lost half of his men; it is enough to obtain a marked superiority at the beginning of the action to discourage the adversary and make him speedily abandon a hopeless struggle.

In order that ships may make the superhuman effort that alone can assure victory, the combatants must not be oppressed by fear of having to repel counter attacks.

It is the rôle of the reserves to keep off disturbers.

IX.

Reserves.

The utility of reserves is questioned. Among those who advocate them, there is no agreement either as to what should be done with them or as to the type of vessel of which they should be composed.

An opinion frequently put forward is the following: When the battle is at its height, the arrival of a fresh force will decide the fate of the day.

This theory is open to discussion; it is true or false according to the circumstances.

Let us first suppose that at the moment when the new units enter upon the scene, the side to which they belong has already been beaten. There is no evidence that the reserve, encountering vessels exalted by victory, will retrieve the fight; and it cannot be admitted that this same reserve will remain impassive while its own side is being overwhelmed. If the enemy is inferior in numbers, the formation of a reserve offers him his sole chance of safety by allowing him to oppose all his own forces to a fraction of his enemy's and to beat them in detail.

Now let us suppose that victory remains doubtful, or leans to the side of the one who has saved for himself a reinforcement. There can be no doubt that the arrival of the latter will contribute to finish the work already begun; but the question is whether the same result would not have been more easily obtained, and more completely, by bringing into action from the beginning all the ships so as to break down the enemy's resistance at a single blow.

In one case, as in the other, the efficiency of reserves is not manifest.

When large fleets meet, there will doubtless be a tendency to bring vessels onto the battlefield in successive groups in order to give to the battle a fixed orientation in which the various groups will act in concert. The ships that arrive last will not form a reserve properly so-called; their delay in coming into action will be of short duration and will depend only upon the soundness of judgment and promptness of decision of those in command.

The formation of a reserve that holds itself outside of the battle-field is a conception evidently inspired by combats of troops. It would take too long to investigate here the difference that exists in this regard between land and sea operations. We will merely remark that the object of the reserves of armies is to secure *economy of force* and that this principle is not applicable to ships on account of their different environment.

It has been proposed to form a reserve of armored cruisers. That would be a means of utilizing them. Too frail to endure the fire of battleships at the opening of an action, they would be given the duty of finishing the wounded. This duty would suit the coast-defence vessels better, for it is the heavy armor that will resist longest, and the cruisers have no means adequate to pierce it.

Whether we consider cruisers or coast-defence vessels, their utilization as a reserve corps in the actual case would not arise from any tactical need, but from the wish to give these vessels something to do.

It would be an error to believe that there are no instances of the rational employment of a reserve in naval actions. It is known that Villeneuve, before Trafalgar, had formed a squadron of observation that was to hold itself to windward of the line so as to be able to bring assistance rapidly to the point attacked. In the opinion of distinguished critics this was the only way to reply to the English flank attack that Villeneuve had foreseen with a sailor's sense, for which he has not been given enough credit.[39]

Nelson had planned to fight this same battle by dividing his forces into two columns; while the first (the most numerous) would constitute the main force under Collingwood, Nelson, with the second, was to protect it from renewed attacks.

We therefore see the theory of a reserve manifested under two different forms in the same battle. The first plan, that of Villeneuve, was justified by the leeward position of his fleet,

[39] Unfortunately, Admiral Gravina, who was at the head of the squadron of observation, seems not to have understood his chief's instructions, and took the head of the line as soon as signal was made to form order of battle, which in fact destroyed the special rôle of the forces he commanded. Jurien de la Gravière believes that Villeneuve himself decided not to have a reserve. Nevertheless the squadron of observation cruised to windward of the line after the departure from Cadiz, and no signal was made to it to quit its post.

which obliged him to receive the attack and to wait until it was developed. It can still find an application to-day. We can imagine a reserve corps, held back from the main body and intended to reinforce immediately the point against which the enemy makes his principal effort; but it is preferable to impose one's will upon the enemy rather than to submit to his. We shall, therefore, only retain the second plan, which is always correct.

This second plan assigns to the reserve the task of preventing counter-attacks. At Trafalgar, Nelson did not carry out his project because the feebleness of the breeze rendered useless the rôle that he had reserved for his column; but he had already illustrated the principle of reserves at Saint-Vincent, when the *Captain*, which he commanded, stopped the *Santissima Trinidad*. Suffren had had the same idea at the battle of Madras, when he placed the *Héros* so as to prevent the head of the enemy's line from putting about to carry aid to the rear guard.[40]

On these two occasions the *Captain* and the *Héros* played the part of a reserve.

Small in numbers, since the principal effort is made elsewhere, the reserve must make head against superior forces, and this seems to be a manifest contradiction. The contradiction, however, does not really exist because the immediate object of the reserve is not to fight, but to contain the enemy; well, it is possible to hold back numerically superior forces during a very short interval of time.

For that it is needful not to engage fully[41] and yet enough to compel the enemy not to neglect your presence. Moreover, to turn a column, it is enough to turn the leading vessel; the rest follow.

In spite of all, the reserve will have a difficult task to accomplish, and usually the commander-in-chief will himself lead it. It may suffer losses; that is the fortune of war. In all great battles, troops have been seen to support the weight of overwhelming forces, and it is necessary to accustom ourselves to the idea that

[40] ". . . . At 4 o'clock I made signal to double on the rear, and to the squadron to approach within pistol shot . . . . I did not set the example in order to hold in check the three leading ships that by putting about would have doubled me . . . ." (*Suffren's report to the Minister of Marine.*)

[41] Considerations of range may then come into play.

it is often necessary to make sacrifices to secure victory, but one must know how to make them at the opportune moment.[42]

The formation of a reserve can scarcely be thought of except in the case when the fleet is composed of several squadrons, but it in no way implies the idea of the separation of forces. Although the position that the reserve will occupy cannot be laid down in advance, since it will depend upon circumstances, it may be said that the best means of making sure of mass is to keep it in one's neighborhood until the enemy's intentions have been made known. In this position of waiting, the reserve will not merely look on at the combat; it will utilize all the guns that are able to fire and it will not be of any less avail because of the fact that the enemy's fire will be turned upon the vessels engaged in the thick of the action.

It is well to establish a clear distinction between the services required of the reserve and those that are attributed to the order of battle. In a formation, vessels are protected by the positions they occupy relative to one another. They, therefore, have a double task: to fight and to afford each other mutual support. These two requirements are contradictory. Moreover, the protection is passive.

The employment of reserves, on the contrary, divides the rôles. A part of the vessels fight without regard for anything else; the rest protect them; and the latter, free to move as they will, furnish the former a protection all the more efficient that it is active and conforms to the exigencies of the moment.

[42] "When," said Napoleon, "shall I find an admiral who will consent to lose four or five ships to win a battle." And elsewhere: "Where have French admirals learned that war can be made without running any risk."

X.

Pursuit.

Up to this point we have seemed to turn aside from the object that we originally set before ourselves (the destruction of the enemy), since we have reduced our pretentions to attacking only a part of the hostile forces. The pursuit brings us back to it.

When a fleet has lost ships and despairs of retrieving the contest with those that remain to it, and whose morale has been affected, it yields the field of battle and seeks to escape, usually under cover of the night. Such a decision may even be arrived at much sooner by those in command, if a sudden attack has thrown their ranks into confusion and destroyed the cohesion of their forces. For the victor, this is the decisive hour; the results that can be obtained on the battlefield are necessarily limited, unless there is such a disproportion of forces as to transform the action at its outset into a pursuit. It is almost impossible to make an end to an adversary who possesses the same arms as ourselves and knows how to use them; as a rule only sufficient harm will be done him to lead him to abandon the struggle and take to flight. The results of pursuit, on the contrary, are without limit.

On land, the material losses that occur during battle are never very great, but as soon as the enemy turns his back, he is picked up in batches on the roads.

At sea the situation is the same from the moral point of view; materially, it presents itself under a different aspect; losses have a more considerable importance on account of the restricted number of fighting units, and, although the respective positions of the combatants may themselves imply a manifest state of inferiority for one of them, it is usually the one who has suffered least who will be the victor.

In the old navy, pursuit was the exception and not the rule. This arose from the fact that the motive power of ships was unprotected and always suffered damages during the battle. The victor having all his forces closely engaged, his ships all had repairs to make to their masts and rigging, while the vanquished,

abandoning his wrecked ships, fled with the rest, a part of which sometimes had not fired a single cannon shot. Nevertheless, whenever circumstances have permitted pursuit, we observe that it has produced results that, the same as on land, have been much more important than those given by the battle itself. Thus at Beachy Head, Tourville sank only two enemy ships, while he destroyed ten during the fortnight that followed. La Hogue did not cost us a single ship, but the subsequent pursuit made us lose fifteen. When M. de la Clue, with seven ships, had to encounter Boscawen's fourteen, he only lost the *Centaure;* only two ships were able to escape in the chase that followed the battle.

The consequences of pursuit are not limited to the destruction of a certain number of vessels; it disperses those that succeed in escaping and thus realizes the object of battle, the complete destruction of the adversary as an organized force. Let us see what became of Tourville's fleet after La Hogue. We have already said that, out of forty-four ships, fifteen were destroyed; three went directly to Brest; four entered the Strait of Dover and went around England; the remaining twenty-two took refuge in Saint Malo. France had only lost fifteen ships, but her fleet was annihilated, and it took more than a year to form a new one. On October 20, 1759, the twenty-one ships under M. de Conflaus are attacked at the entrance to Quiberon Bay by thirty-three English ships. Fighting in retreat, two ships are sunk and a third captured on the 20th; the *Juste* is lost on a reef on the 21st; the *Héros* and *Soleil-Royal* are burned on the 22d. Total, six ships lost. Of the fifteen remaining, eight succeeded in reaching the island of Aix; the other seven take refuge in the Vilaine, whence they go out only much later and separately. Until the end of the war, France was unable to get to sea a force sufficient to hold in check the enemy, who devoted himself without interference to a series of depredations on the coasts.

"At the present time," we added, in the first edition of this study, "the motive power of warships is the object of a special protection. It may, therefore, be foreseen that the victor will have more ships available than the vanquished, contrary to what formerly occurred,[48] and pursuit, therefore, assumes a capital importance in our time. Even in case the battle has not given

[48] Vessels unprotected forward are the exception; they will only be able to give a reduced speed, even if their machinery is intact.

any decisive results, nothing is lost if one is in condition to follow it up with an energetic pursuit."

Let us apply these principles to the two great battles of the Russo-Japanese War that have occurred very opportunely to reinforce our argument.

On August 10, the battle had no material result; but the Russian squadron, which was without any specific orders, was dispersed in all directions. The Japanese, surprised at their easy success, did not think of organizing a systematic pursuit until the following day. They thus allowed the main body of the fleet, composed of five armored ships, to re-enter Port Arthur; but they forced the *Tsésarévitch*, *Bezpostchadnyi* and *Bezotrachnyé* to disarm at Tsing-tao; the *Askold* and *Grozovoi* to disarm at Shanghai; and the *Novik*, which they could reach, to be sunk at Korsakov. Such were the results of even a tardy pursuit.

Doubtless Admiral Togo, taught by experience, promised himself that another time the Russians should not get off so easily, and he kept his word. The battle of Tsushima was already a magnificent success; but the pursuit procured still more surprising results. Four battleships surrendered with Admiral Nebogatov in the vicinity of Liancourt rocks; the *Svietlana* and *Bystryi* were sunk near the Corean coast; the *Admiral-Nakhemov*, *Vladimir-Monomakh* and *Gromkii* were sunk to the east of Tsushima; the *Sissoi-Veliki* was sunk to the northeast of Tsushima; the *Admiral-Ouchakov* was sunk south of Liancourt rocks; the *Dimtri-Donskoï* was sunk near Matsoushima; the *Biedovyï* surrendered with Admiral Rozhestvensky; the *Izoumroud* was lost at the entrance to Vladimir Bay; the *Oleg*, *Aurora* and *Yemtchoug* disarmed at Manila; the *Bodryï* and *Bouinyï* sunk at sea; the *Koréa*, *Svir* and *Blestiatshii* disarmed at Shanghai.

In brief, of thirty-six vessels, only two torpedo-boat destroyers and a small cruiser reached their destination. Thanks to a splendidly planned pursuit, the battle of Tsushima occasioned unprecedented losses to the vanquished.

Pursuit has a different character from battle in retreat, such as we have imagined it. In the latter, the enemy adopts this method of fighting of his own choice; he preserves his unity; he is ready to face whatever may happen; in a word, he fights. In the pursuit, he abandons all idea of resistance; his principal aim is to escape, and he will only fight to the extent that is necessary to

help his evasion. If he stops, he lessens the range; if he tries to succor laggards, he risks being himself caught, which is precisely what he is seeking to avoid. Forced to assume his highest speed, the chase puts his means of locomotion under a tension that risks breaking them down; the sailing ship carried away masts and yards and tore her sails; the steamer will have hot bearings. In all sorts of ways he has to meet contradictory requirements, and the situation that arises from them puts him in a critical position that is the prelude of a disaster. It offers so few chances of safety that it may be asked whether it would not be cheaper to pay with one's life than to fly, unless evasion is favored by darkness. To our knowledge there is but a single example of a naval force having been able to escape unhurt.[44]

The pursuer's line of conduct is plain to be seen; it should be such as will tend to arrest the progress of the enemy by harassing him with the fastest ships; but one should act with relative prudence if the pursuit is not the sequence of a battle and results simply from numerical inferiority. In the latter case the enemy has all his ships intact and is capable of giving hard knocks. This consideration ought not to prevent pressing him hard, but the leaders should take advantage of their freedom of movement (which the enemy does not possess) to place themselves in the sectors least swept by gun-fire. If the chase wishes to shake off the clutch of his pursuers, the latter have only to fall back on their supports, and they will thus have made the chase lose ground.

On the contrary, when the pursuit follows upon a lost battle, the enemy will be more or less in disorder; his ships will have suffered to different extents. There should then be no hesitation in casting aside a prudence that might permit the chase to escape, and in always pressing on, the fastest leading, each ship passing the laggards without stopping to engage them so long as there are other ships behind it to pick them up.

Nothing should stop the pursuit. Everyone knows to what unforeseen damages engines are subject, and by persevering the ground lost during several hours may be made up in a few

[44] On June 17, 1785, Cornwallis, with five ships, was chased by Villaret-Joyeuse's whole squadron without losing a single ship. This exception explains itself when the details of the affair are read, and when the respective states of the two navies are taken into account.

minutes. The night itself, which, according to the saying, separates the combatants, ought not diminish the pursuers' ardor; the enemy may be found again at daylight; even if left alone on the horizon, one should continue in the direction of the line of fugitives. Only in the vicinity of the enemy coast should the pursuit be given over, in order to avoid contact with ships that have not suffered the demoralization of a lost battle; and on the return route there will still be opportunity to pick up booty that has slipped through the meshes during the night.[45]

[45] It may happen, when the disproportion of forces is not sufficient to destroy all chance of fighting with honor, that a naval force will retreat with the sole object of causing the enemy to divide and extend his forces. It will then be in a good position, by a rapid turn-about, to engage with advantage. This is a snare that must be avoided, but there is no rule that can help out good judgment.

XI.

Night Battles.

It is difficult to believe in the possibility of fighting in the darkness without the occurrence of unfortunate confusions. How maintain unity of control at night? How recognize the enemy's position? It would seem that a night action must occasion a mere mêlée in which it will be difficult to distinguish friend from foe, or end in an artillery duel that will be very much lacking in precision.

In history we find but a single night battle between important forces: Aboukir. And it was fought at anchor and begun in daylight. Later we find the battle of Gibraltar, in which Admiral Saumarez, with five of his ships, attacked four belated ships of the combined fleet, without the main body daring to do anything to extricate its rear guard.[46] Outside of these two battles, there have been quite a large number of night encounters between ships cruising alone or in couples.

Fighting has, therefore, only been done at night when the circumstances permitted the avoidance of a confusion of ships. We should not conclude from the foregoing that this sort of battle will only take place under similar conditions, but merely that it is necessary to be wary of rashly entering an impasse. The day when a man who understands war succeeds in overcoming the difficulties that we consider insurmountable, he will not hesitate to engage in battle at night because he will find a new element of success in the possibility of masking the movements of his forces.

In any event, it will always be possible to take advantage of darkness to throw a numerous fleet into disorder with a few well-

[46] The battle of Gibraltar is particularly instructive. It shows that an enterprising mind always finds favorable opportunities, however weak his forces may be. It also teaches us never to despair of fortune, for Gibraltar was only a striking revenge for the combat of Algesiras where Saumarez, a few days before, had lost a ship. Cosmao showed still greater strength of character when, after the disaster of Trafalgar, he set sail from Cadiz to snatch from the English the remnants of our fleet.

disposed vessels, and thus to give favorable opportunity for torpedo-boat attack.[47]

It must be added that the night is reserved for the attacks of torpedo-boats, and that is a reason why, in present-day fleets, there are no nocturnal encounters between large vessels; for the latter should leave the field free so as not to expose themselves to the risk of being taken for enemy ships.

If there had not been torpedo-boats in Admiral Togo's squadron, the battle of Tsushima might have been followed by a night action.

[47] See the *Indefatigable's* maneuver in the night of December 16, 1796, during the sortie of Morard de Galle's squadron (Hoche's expedition to Ireland).

XII.

Signals.

There are signals and signals. Some have only a conventional interest, such as those that indicate the beginning and end of an exercise; others have a character of absolute necessity and are used in cruising; finally, there are battle signals, the importance of which is fundamental. We shall concern ourselves only with the latter.

It makes very little difference, in the ordinary routine of service, whether our signal books are more or less thick, more or less complicated. It is a very different matter where battle is concerned.

A useless signal produces uncertainty in the minds of the combatants; a signal misunderstood leads to disorder; a signal impossible of execution denotes, on the part of the one who makes it, a wish to put the responsibility on others. It is therefore necessary to use every endeavor to make as few signals as possible. Moreover, they will have so much the more force as they are infrequent.

This is not to say that the code of battle signals should be suppressed or diminished. Unless he is to abdicate all authority, the admiral must have means of making all the communications that he judges useful. He will try to reduce them as much as possible because the enemy's fire will soon disintegrate the sets of flags and he may find himself powerless to communicate his thought; but so long as the means are not lacking to him, he will make use of them.

In spite of all this, it will always be prudent to give sufficiently precise instructions for it not to be necessary to complete them by signals. The conduct of each during the battle can only be guided by exact knowledge of the situation, and if the admiral has not accustomed his captains to act on their own responsibility, *according to his general plan,* no signal will be able to remedy the faults and errors that will occur. More must not be required of signals than they are able to give.

The councils of war that have followed our great disasters put in evidence the inefficiency of signals. Unfortunate leaders always complain bitterly of the non-execution of their orders; they forget that orders are of no avail to retrieve a battle badly begun, and that, if they had led their vessels on the road to victory, they would not have been obliged to depend upon displays of signals. At Aboukir and at Trafalgar Nelson made but a single signal that clearly indicated the objective he aimed at; the conduct of each one followed from it as a matter of course. At Fou-chéou, Admiral Courbet likewise made only one signal, but it was misunderstood.

Among the orders that it may be desirable to give during battle, there are a certain number that are urgent. It would be well to collect them together in a special signal code, and to seek a simple and rapid means of transmitting them.

The question of signals is, however, intimately connected with tactics and command, and we shall have occasion to return to it incidentally.

XIII.

Cruising Tactics. Battle Tactics.

We have examined the three phases of battle that result from the very nature of things: the approach, the battle properly so-called and the pursuit. Each of them calls forth one of the three military virtues that constitute the strength of armies. The first requires skill; the second, vigor; the third, tenacity.

In the course of this study we have attempted to bring out the general laws revealed by actual occurrences. What we have to do now is to apply them with the means that the actual navy furnishes. We, therefore, open the tactics, and we find in it a complete collection of naval geometry; but a rapid examination will suffice to convince us that the duration, precision and rigidity of the movements it contains could never endure the atmosphere of the battlefield.

Evolutions necessitate speeds laid down in advance, known turning circles, a distance measurer and, above all, a compass. During battle the compass is out of use, the distance measurer leaves the bridge, and the commander shuts himself up in a conning-tower, where the space allotted to him is about as much as that of a sardine in its box. It will therefore be impossible to maneuver.

Formations, although less methodical, require none the less the same elements, and line ahead is about all that remains capable of being employed.

The worthlessness of our official code arises from the endeavor to make it at the same time a tactics for cruising and a battle tactics. It more than satisfies its first purpose because, as there is much cruising and no fighting, cruising tactics has quite naturally taken precedence over battle tactics. Yet, since conditions are not the same, there cannot be a common means without one of the objects being sacrificed to the other.

To cruise is to conduct vessels from one point to another with the order and method that alone assure their safety. During battle, order (geometric) matters less than unity of control;

method, which entails delays, interferes with rapidity of execution. Finally, the capital point is that the enemy has to be taken into account, and that, while endeavoring to impose one's will upon him, one is, nevertheless, subject to the influence of his presence; whence arise movements that are neither formations nor evolutions, and to which it is impossible to assign a geometrical or symmetrical form. In a word, we cruise alone, and there must be two to fight.

Cruising tactics exist, function and meet all requirements. They can therefore be kept as they are. It would certainly be possible to make them less extensive by doing away with a certain number of movements that constitute merely an exercise of naval *haute école;* but that is an unimportant matter.[48]

Battle tactics should have quite another character. They are merely an instrument that, in the hands of the chief, must play true, that is, must conform to the necessities of the battlefield. One cannot do as he wishes under the enemy's fire, and the number of movements is limited; but that of combinations is not, because each is composed of parts common to several others.[49] Moreover, it is less the means that differ (on condition that they are appropriate to the circumstances) than the opportuneness of making use of them. Furthermore, whatever the means may be, if they do not suit the object that is proposed, they paralyze the action of the best equipped leaders.[50]

Tactics does not give victory, for it creates nothing (genius alone is creative); but it furnishes to those who make use of it the means of obtaining victory. On the other hand, it can avoid defeat by furnishing useful indications. In any case, it does not direct battle; otherwise it would be like those Barbary organs that always play the same tunes.

The characteristics of battle tactics are simplicity and rapidity. Simplicity, because the field of battle is not suited to such a disturbing element as complication; rapidity, because that is the only way of getting ahead of the enemy. These two conditions fix

[48] What is more serious is confusing the minds of officers whose heads burst with the effort of memory that is necessary for finding one's way in the labyrinth of everlasting essays.

[49] Just as with ten figures all numbers can be composed.

[50] Example: Suffren, whose genius shattered itself against the wall of the old tactics.

bounds that tactics can never exceed without departing from the right path.

Battle tactics can only be constituted on the field, under conditions approaching reality as closely as possible, that is, by the maneuvers of opposing forces. That is the sole manner of avoiding hopeless errors. It frequently happens, in fact, that creations of the mind are found to be impossible of realization when it is wished to embody them in act. In general, they are inspired by an attractive idea the application of which brings out obstacles that had not been foreseen. Well, what would happen if battle were based upon movements that had not received the confirmation of practice? Insurmountable difficulties would be encountered, and the battlefield would become a field of experiment. In war it is especially important not to have the right idea that comes too late; in war one must not have to say when all is over, that is what ought to have been done.

Battle is a problem that contains a great number of unknown quantities. By exercises carried on systematically for years and years we will succeed in determining some of them. This labor will to a certain extent lighten the superhuman task of the leader; it will relieve him of a part of his anxieties and allow him to bring the whole power of his intelligence to bear upon other unknown quantities that can only be elucidated on the spot. There are many situations that are not susceptible of an indefinite number of solutions;[51] yet it is necessary to study them so as to recognize them. They will then serve as a bond between the commander-in-chief and his captains when the latter are left to their own inspirations. Most attacks are only valuable from their suddenness; the agitation that it causes prevents recovery. If there is no surprise, the return stroke may be fatal to the aggressor. Therefore, whether attacking or defending oneself, it is needful to know in advance the risks that one runs.

We have a natural tendency to repel everything that is new, because novelty involves a certain amount of uncertainty. We forget thus that the field of possibilities increases constantly with progress, and we continue in ways the reasons for which have

[51] Example: When the rear of a line is threatened, there are two ways of succoring it: by bending the head back upon the rear or by turning head to rear. The latter method seems preferable, but it makes a difference which way one turns.

long ago disappeared. Moreover, the commonest maneuvers, such as those that consist of entering a port or going through a passage, always offer a certain difficulty when executed for the first time; they cause a mental strain that prevents paying attention to something else. On the contrary, difficult maneuvers (we do not say complicated) are carried out so easily, when frequently repeated, that one asks himself how they can ever have been found trying. In the beginning of steam navigation, the line ahead was thought to be the most dangerous order for cruising; to-day there is no more handy formation.

When cruising at night without lights was first tried, it seemed like inviting accidents; to-day all apprehension concerning it has disappeared.

Let exercises be surrounded with all desirable safeguards; let us pass from simple to complex, meeting difficulties as they arise; but there is no need of recoiling from difficulties that are often more imaginary than real.

Double-action exercises have had but little development in our navy. In the present state of our armaments, it is seldom possible to constitute two forces sufficient to be opposed one to the other. It could only be done at the period of mobilization when our squadrons are brought together.[52] But each time that these exercises have taken place, they have brought out points that were in obscurity. If it had been possible to do them over again at once, each side would have modified its method of action. They teach something therefore. Are they not obligatory, moreover, under all circumstances where one has an active force opposing him? Is fencing practiced without an opponent? In the case of the army, is not the enemy represented?

We sometimes hear it said that double-action exercises would only give rise to a limited number of movements, and that their interest would soon be exhausted. That is an error. The mere fact of one force being opposed to another brings out new ideas;

[52] The resources of tactics, in fact, increase very rapidly in proportion as the number of vessels increases. In contests between single ships or detached divisions, they are very feeble. We must take care not to wish, at any cost, to secure from tactics more than it can give, under penalty of falling into fantasies. Nevertheless these exercises are useful, for if they do not teach what should be done, they at least show what should not be done.

one finds himself faced by situations of which he had not thought; on both sides it is sought to derive advantage from it, and again the unexpected is created. Then each man does not use the same methods, and it is the aggregate of all preceding observations that constitutes the tactics. The latter is a book that is never finished.

Double-action maneuvers play in tactics a part similar to that which history plays in strategy. The study of wars, in fact, makes us see events in their true light and in their varied aspect; it reveals to us all the combinations that the fertile minds of men have brought forth in the course of centuries.

XIV.

On Command.

The object of command is to unite and concentrate all the scattered forces that are represented in each individuality, and to bind them together. It manifests itself by the subordination of all wills to a single will.

Command is not the logical product of our military regulations; it is a social necessity. When it does not exist, it creates itself and imposes itself.

The great majority of men have need of being governed, and a small minority have received special gifts for directing the masses. Under the ordinary circumstances of life, this need does not make itself felt, and the instinct of independence incites us to free ourselves from all tutelage; but when danger appears, the crowd abdicates in favor of the most worthy and command shows itself then in its true light, very much more a protection than a trammel. Each one of us has been able to note it in those situations, so frequent in cruising, that are, if not dangerous, at least difficult. The whole crew looks towards the commander, calling upon him to get the ship out of the tight place in which it finds itself; at this critical moment the strongest willed scarcely think of contesting the leader's authority.

It may be useful to inquire what resources superior men who have been invested with command have known how to derive from it. They generally had at their disposal only the same means as their adversaries, and yet they have gotten more out of them. The explanation appears to reside in the fact that they look at things from a point of view peculiar to themselves.

In all epochs, mathematical speculations, which are based upon fixed and known data, have influenced ideas in military matters. When they have assumed a preponderant importance in the conception of war, they have ended by fixing it in a rigid mold.

It is always so in the long periods of peace, because the causes that modify the value of the factors do not manifest themselves, while the physical data are always before our eyes. The result is the creation of a system of war that is deduced systematically from absolute calculations of the strength and number of weapons.

Great captains proceed differently.

For the ballistic value of weapons, they substitute the real value. The latter is affected by the special conditions of the battlefield to a degree that varies according to the circumstances of each occasion. At the same time they draw upon the human machine to its utmost, and make use, as from a veritable reserve, of the property that the strong man possesses, by the concentration of all his faculties, of doubling and tripling his strength at a given instant. It is only a straw fire; it is necessary to make it flare up and to use it at the opportune moment. It may be seen, therefore, that they operate in a field much more vast than that of common mortals, and that the scope of their plans puts to rout all previsions. It is for that reason that we often consider operations bold and rash the success of which, far from depending upon chance, has had for origin an exact estimation of the situation.

The method of great leaders has this other peculiarity that they have never sought to be sparing of their forces, and that the greatness of the result concerns them much more than the losses they may suffer. On the contrary, it is this latter phase of the question that regulates our conduct, and the thought of the sacrifices to be made influences our determinations and makes us recoil *a priori* from certain eventualities. So it is that we constantly hear it said that torpedoes make the entrance of harbors inviolable; nevertheless, Farragut forced many passages and he did not escape without some losses; he had ships sunk by torpedoes. But who can therefore assert that Farragut did not succeed or was wrong in undertaking to force passages?

Let us say, finally, that the simplicity of the plans of genius proves that the difficulty consists less in defining what it is needful to do than in having the energy necessary to carry out successfully what has been decided upon.

In our future wars the exercise of command will be particularly difficult. The contest will be begun with a new material whose power is not exempt from disadvantages; nobody will have that sense of what it is possible to do which is only acquired by practical experience. Such a situation is without precedent. Until the present epoch the men who have left a name had passed through the different grades of their profession during periods of war, and it was this continuous contact with the enemy that gave

them the exact idea of their strength and revealed to them the weakness of others; in a word, they had an experience that alone enabled their genius to take its flight.

We have the recent naval wars to guide us, to be sure; but we did not take part in them as actors, and it is quite a different thing to read an account of a battle and to have been in it.

In fact, there is scarcely anything available except the results of firing-ground tests; we know the power of a gun, the number of rounds that it can fire per minute, the thickness of the plate it can pierce. All of which constitute the elements of power and not those of efficiency. It is not enough, for the latter alone are of use in carrying on war. There is a hiatus here that everyone is aware of and that hitherto has been filled up with considerations upon the capacity of the personnel. Well, it won't do to suppress anxiety about the future by drowning it in a flood of bombastic phrases, for though a leader may estimate the strength that he draws from the feeling of his personal worth, he can only measure that of the weapons put at his disposition if he is furnished with means of doing so. Evidently exercises and experiments that could be made with a view to determining the efficiency of the weapons and the strength of resistance of the vessels would give rise to conclusions that would not be beyond appeal; they would be full of errors from the fact that the enemy does not fire back; but they would give an indication from which the judgment of a leader will know how to draw profit.

It may likewise be remarked, concerning the difficulties that command will encounter, that all the great warriors have appeared upon the world's stage at epochs when the military art was passing through periods of stagnation and was so conventional that it was always known just what the enemy would do. This certainly furnished a point of departure that will be totally lacking to-day.[53]

Let us now view command in its relations towards subordinates.

The medium of centralization, it can be exerted in two different manners. The first tends to bring all the machinery under the direct control of a single person who acts in stead and place of the rest; the second blends all wills in a single one by impressing upon them a uniform conduct, while leaving to each the free disposal of his means in his proper sphere.

[53] Military men of genius have invented nothing; they have simply brought war back to its true concept.

The first system is suitable for cruising, where individual initiatives would cause confusion, and where the unexpected seldom happens; each vessel has only to carry out orders passively and to keep its position.

During battle the situation is reversed. The unexpected becomes the rule and requires immediate decisions. Well, whatever the authority of the chief may be, he will never have more than mortal sharpness of sight; from his post he will not know exactly what is going on at the extremities of the battlefield; his attention may be occupied elsewhere. On the one hand, the perspective is deceptive; on the other, signals are only formulæ the general meaning of which tends to ambiguity when it is wished to apply them to a concrete case. Under these conditions it is materially impossible to control vessels at a distance, as if with reins, without making mistakes; directions will have to be substituted for routes, and for the rest it will be necessary to trust to the intelligence of the captains.

Nevertheless, there are not wanting people who think that the initiative takes away from command a part of its authority and prerogatives. That is a narrow view to take of things. Command is, above all, a moral affair, because it is exercised over men who think and act; it does not consist in the substitution of the action of one for that of all; it subjugates the wills that engender acts and not the acts themselves, in such a way that each acts as the leader would have acted. Command gives the impulse, it determines unity of action, but it neither thinks nor acts for everybody.

In all battles individual initiative has had to intervene, and it has sometimes decided the victory. Has a leader the right to deprive himself of the aid that it may afford him? Will it be necessary, in order to satisfy considerations of self esteem or of sentiment, to condemn Nelson's maneuver at Saint-Vincent and that of Captain Foley at Aboukir? There are those who would have us think so. Yet individual action, however brilliant, in no way diminishes the glory of the leader, since it is to him that the honor of it reverts. No one has thought of denying to Nelson the merit of the victory of Aboukir under pretence that Foley, by doubling the head of the enemy line, made a decisive movement. The latter acted on his own initiative, but, although inspired by a situation of which the admiral could not judge, he was only making application of Nelson's proposition that wherever an

enemy ship had room to swing at anchor one of his ships could find space to anchor.

How many defeats would have been avoided, or at least minimized, if the captains had had the least initiative! And it was not a matter of their having to execute some brilliant maneuver, but merely of their going where duty called them.

The admiral will most often be ignorant of the enemy's intentions; he will therefore be able to give to his instructions only a very general meaning. If one finds himself face to face with an unforeseen situation, will it be necessary to wait passively for directions? If a ship finds itself without an adversary, ought it keep the same station? There can be no doubt; it is necessary to go where the fighting is.

But the admiral has made no signal!

What matters it! Do you know whether he can see what is going on? Do you know if he is still able to hoist a signal?

Yet many a ship, in many an encounter, has afforded the desolating spectacle of an absolute passivity. The captains hesitated, were irresolute, *asked advice.* Time passed; the situation grew worse and when finally a decision was reached it was too late.

What were Villeneuve, Decrés and Trullet doing at Aboukir while three-quarters of the French fleet was being beaten? Trullet, impatient to get under fire, hoists his topsails, waiting an order from Decrés. Decrés waited for an order from Villeneuve. And Villeneuve? Was he waiting for a night signal from the *Orient* that already was in the throes of death under the attack of three enemy ships? Under these critical conditions, was it needful to seek to retrieve a compromised situation or to save a few remnants from the disaster? The question is debatable. But the need of reaching a decision one way or another, and of deciding immediately without waiting for the morrow, is not debatable.

And Dumanoir at Trafalgar! It was three o'clock when he went about to go to the assistance of the center and rear. It was not at three, nor even at noon, that he ought to have decided.

It was at the instant when the attack developed and it became evident that he was to be left without adversaries. To await the transmission of a signal would have been losing time; the destinies of a squadron ought not to depend upon flag halliards.

But there was no breeze.

There was enough for Nelson's column that passed so close to

the French van that they exchanged shots; there was still enough an hour later for the English ship *Africa* that passed along the whole line to go under fire.

Leaders who stifle the initiative of their captains should never complain of having been abandoned on the battlefield.

The duty of command is, therefore, above all, to instruct each one in advance what he will have to do in order to start the battle in the right way; thoroughly to instil into all the subordinate admirals the principle that they must never regard the situation from their individual points of view, but that they ought solely to concern themselves with the effects that their personal actions will have upon the result of the battle. Whatever may happen afterwards, the impulse given will not cease to act. Who would dare to assert that while Nelson was dying in the hold of the *Victory* his squadron was no longer commanded?

It is the same in all the stages in which command is exercised. We see on our ships all the organs of control centralized in the conning-tower by means of speaking-tubes and electrical apparatus. It is quite certain that a commander has reason to be proud when he contemplates the size of his ship, the weapons that it carries, the men who man it; he feels a sentiment of pride in thinking that this colossus obeys his voice and that he regulates its least movements. During battle, this is but a dream. Fatal dream! If the commander pretends to concentrate in himself the duties of all the officers; if he pretends at the same time to command at the helm, to indicate the target, the shell, the vessel to torpedo, he will be unable to fulfil these numerous occupations; he will neglect part of them to absorb himself in the one that most urgently requires his attention, to the great cost of the general working.[54]

[54] Here is the idea of the command that we find in an American work (*Tactics of ships in line of battle,* by Lieutenant Niblack):

"A commander ought to have four things under his immediate orders: the speed, the course, gun fire, torpedo fire. Moreover, he ought to be in a position to know at each moment by means of the interior communications: 1. The helm angle. 2. The number of revolutions. 3. The distance of the enemy. 4. The distance and bearing of the guide vessel. 5. If each division is ready to fire. 6. If each torpedo tube is ready to fire. 7. The hull damages. 8. The number of degrees of list."

The officer who has to meet all these requirements is nothing more than a registering apparatus.

Every officer habituated to obey automatically will cease to foresee and will lose all initiative. When circumstances compel him to come to a decision, he will decide wrongly or will not decide at all.

The drawbacks of this system will appear after the battle, when the time for recriminations has come; then it will be perceived that human intelligence is a better organ of transmission than an electric wire, and that a man's faculties, even though he be in command, are not unlimited.[55]

The work of times of peace is to train the personnel and to teach each one what he will have to do, in such a manner that during battle the officers of the various grades can devote themselves to the occupations that are born with war and only appear on the battlefield. The subordinate officers especially will have a rôle of general supervision to keep everyone at his post, to strengthen courage and to meet unexpected needs. As for the commander-in-chief and the captains, all their attention will be concentrated upon the enemy, whose movements they will follow in order to profit by the least sign of weakness. In war, it is the opportunity that makes the thief; to profit by it, it is necessary to have a free mind and not to be absorbed in details; it is also necessary for the machinery to be in such good condition that, once set going, it will keep on working.

[55] Let us take as an example the torpedo service. There is a greater and greater tendency to make it dependent on an electric bell and to centralize it in the hands of a single officer who, himself, is only to fire when the target is pointed out to him. Torpedoes will only come into play when the action is at close range, and the commander will have so many things to do at this moment that he may very well neglect to indicate the target. Nor is it at all improbable that several objectives will present themselves at once and on different sides; so that the torpedo officer will not be able to direct all his tubes and will let chances escape. Is it necessary, then, to fire torpedoes only upon the captain's order, and cannot the latter give his instructions before the battle? Will not any torpedo that hits an enemy's vessel be good? Is it necessary to be a lieutenant to use the sighting apparatus? Should the death of the torpedo officer, the destruction of the central sighting station, or the breaking of communications entail a complete stoppage of the torpedo service?

That material centralization be submitted to as a necessary evil when nothing else can be done, may be understood, but all that tends to lighten the burdens of command, without taking from it a bit of its authority, ought to be considered advantageous.

Certainly it is easier to keep for oneself the solution of all problems than to train people to solve them. But that is not the question; it consists of knowing what is the best return that a squadron or a ship can make from the point of view of the organization of command, and where human faculties reach their limit. In forming an opinion on this point, we must not trust too much to observations made in times of peace; for in exercises each one only attributes to himself the part that he can assume, without its being proved that this part meets all the requirements, since there is no penalty. The best indication is still furnished us by the great seamen;[56] of all chiefs of squadron, they are the ones who left the most initiative to their lieutenants, and it may be admitted that, since they acted so, they thought that they could not do otherwise.

* * *

There remain to be considered the physical and moral elements that are auxiliaries of command, in the sense that they give a better utilization to forces and facilitate operations.

The moral elements are the qualities of the personnel: moral strength and will power. The physical elements are the qualities of the material: speed, homogeneousness and nautical features.

[56] Read on this subject Nelson's battle *memorandum* and Suffren's instructions to Tromelin.

XV.

Moral Factors.

Though the methods of war are reacted upon by a material that is undergoing permanent changes, man, who puts in operation all this complicated apparatus, does not change. To-day, just as a hundred years ago, he keeps his susceptibility, passing from confidence to discouragement according to the influence exercised upon him by events and by his surroundings.

It is impossible to understand anything of military affairs if we do not bring into account the moral factor that destroys all combinations solely based on superiority of numbers or of strength.

Moral force is, therefore, one of the factors of battle; without it, the material is worth no more than old iron.

It is drawn from two sources: self-confidence and the situation (not as it is, but as it seems to be). Courage, in fact, is not a natural sentiment. Aside from some exceptional natures that danger excites and which are always ready to rush in, man seeks to defend himself before thinking of attacking. Among officers, courage is born of the sentiment of duty and honor; in the lower ranks, it is developed by artificial means, the chief one of which is the conviction of conquering. But a fortuitous circumstance, such as a repulse, is all that is needed for nature to take back her empire and to transform into runaways people who just before have accomplished deeds of heroism.

Self-confidence is only a consequence of the confidence that command inspires; for troops take very good account of the fact that there must be someone to lead them to victory. A leader who has the confidence of his soldiers can ask everything of them; his orders are accepted as infallible dogmas, and, no matter how perilous their execution may appear, each one marches with pleasure, confident of success and saying to himself: he has his idea. Under the influence of this confidence, man accomplishes acts of which he would be thought incapable. The efficiency of the human machine is, in fact, essentially variable; not only is it not the same in two different nations or in the different armies of any one

nation, but it varies from day to day, from one hour to another, in one and the same force, according to the course of events.

This is because the moral factor is influenced by the local situation.

The same reason that deprives those on one side of all strength, multiplies tenfold the strength of the others because the situation appears in a directly opposite light to the two sides. A vessel that sinks in the midst of the battlefield compromises the battle, and the first one that hauls down the flag gives the signal for defection. Thus an affair badly begun is always difficult to retrieve. Nevertheless, the character of man is so mobile that very little is necessary to change the direction of his thoughts and to revive his hopes. "The battle is lost," said Napoleon at Marengo, "but we still have time to win another."

What a powerful lever moral force can be in hands that know how to exploit it may be understood. The great captains, one of whose qualities is knowledge of the human heart, have made constant use of it. Nelson knew what he was doing when he signaled to his squadron, "England expects every man to do his duty."

The prestige of the victor resides much less in his actual strength than in that which is attributed to him. Whoever has been fortunate in the beginnings of a war possesses a double strength: that which comes from the self-confidence given by first successes; and that ascribed to him by the enemy, which has the effect of rendering the latter cautious.

The superiority of the offensive over the defensive that has become an axiom in military circles is explained solely by reasons of moral order. Under most circumstances the advantages at first sight seem to be in favor of the defence. That is why designs that are wholly based upon material factors inevitably end in the development of defensive methods and discount results that are in flagrant contradiction with the teachings of history.

On land, turning movements, attacks in reverse and surprises have no more solid basis than a moral effect. Men attacked from behind will always be painfully impressed; when some begin to run they draw all the rest after them; and if, at this precise moment, the runaways could be shown the number and position of those who are putting them to flight, they would see that they yield before an imaginary danger.

As soon as a combatant ceases to have at heart the desire to conquer, his first impulse is to escape without defending himself. That is the secret of the fabulous results furnished by pursuit. Regiments have been seen to lay down their arms before a handful of men, and detachments of cavalry to make strongholds capitulate.

The moral factor dominates the field of battle. It exercises a greater influence than numbers, although numerical superiority contributes to strengthening morale and the whole art of war consists in knowing how to make skilful use of it.

In the navy moral effects are less apparent than on land because the crew is shut up within the walls of a vessel and cannot run away; but they exist none the less, entailing the same consequences. A ship is comparable to the human body. The captain is its head, the men who man it are its arms; the head may remain sound while the arms are paralyzed, and there are many chances that the gun-pointer whose heart is stricken with fear will not send his shot to the mark.

The influence of events is felt by the command, moreover, just as it is by the men. History shows us Suffren hurling himself upon the enemy and laying himself open in consequence of his captains' lack of energy; yet Hughes never thought of drawing advantage from the disorder of the French squadron, because he submitted to the moral ascendency of his adversary. Far from seeking to take the offensive, he thought himself fortunate to have been able to escape without disaster from a bad situation. We note with astonishment that the English admiral saw concentrations of forces in what was only the consequence of badly executed maneuvers. During the wars of the Revolution and Empire, moral ascendency was on the side of the English, and they made large use of it to reduce the forces of their blockading squadrons, when they were short of ships, without the blockaded thinking of profiting by the occasion. If critics who amuse themselves by correcting the faults of others took account of the moral state of the opposing forces, they would spare themselves the trouble of fighting battles over again and changing on paper the face of things.

The most brilliant example of the potency of moral force has been given us, in our own time, by Admiral Courbet, whose name

alone was a dread to the Chinese, and took the place of protection on our wooden cruisers.

War will send on board our ships reservists for a long time removed from the influence of their officers. Their state of mind ought to be the object of our solicitudes, and nothing should be neglected to keep up in them moral strength. At the battle of Santiago, the Americans kept the men below decks informed of the incidents of the contest. That has been thought silly by some; but its effect, none the less, was to keep each one at his station and to strengthen courage.

Discipline, self-esteem (especially among the French), the habit of winning, develop moral strength; but it is an inconstant that attaches itself to fortune and takes flight with her.

* * *

Battle is not merely an exchange of cannon shots; it is at the same time a contest of two wills.

Two ships are engaged one against the other. They are commanded by energetic captains, and manned by trained crews. The combat proceeds from stage to stage, but its issue remains doubtful. Fatigue comes over the combatants; each feels his strength waning and the need of making an end is felt; each has enough of it.

At this critical moment, victory no longer depends upon deadly weapons; it is in the hands of an invisible weapon that will decide in favor of the one who knows how to keep it on his side: it is the will to conquer.

Battle, from its nature, exacts of man a superhuman effort that strains all the fibers of his organism; and this abnormal tension can only be produced and maintained by the hope of victory. As soon as that disappears, the reaction at once sets in, and the worn-out man gives up. If he had waited a minute more, his adversary would himself have reached the limit of his strength, for he is only sustained by the feeling that one last effort will secure for him the superiority.

And thus, most frequently, victory will rest with the one who forgets his own fatigues to think only of the adversary. "You are worn out with fatigue," said to us our professor of the military art at the École Supérieure; "the enemy is just as much so, and perhaps more." We sailors can say to ourselves: the ammuni-

tion is almost all gone; the ship is riddled with shot; but the enemy is no better off.

Battle is, above all, a reciprocal action, and however bad the situation may appear we have the right to think that it does not show itself to the adversary in any better light. The aspect of affairs would very often change if, instead of dwelling on our own evil condition, we sought to discover the ills from which the enemy was suffering. It is observed that the vanquished always attribute to the victor superhuman means, transcendent plans, while in reality he has no other superiority than that he exhibits more moral force. A battle is only definitely won from the moment when one of the adversaries manifests the intention of no longer continuing the struggle. Too frequently this resolution has been taken without giving enough weight to the state of exhaustion of the enemy, who thus finds himself victorious at the moment when he feared being beaten.

He who engages in battle with the fixed determination not to be the first to yield is already half victor.

Is it ever known what may happen? A resistance prolonged for a few moments may bring help and change the aspect of affairs; the last shot from the last gun will perhaps inflict the mortal wound. Therefore let us instil into our men the principle that they must hold fast, continue to hold, and never let go. Just as one nervous man (and not a coward) is enough to make a whole company turn tail, so one cool man in a turret or at a torpedo tube will keep the rest at their stations. Even in the most serious situations, man's self-respect always endures, provided there is someone to awaken it.

Beneath the inscription in letters of gold that adorns the fronts of our bridges, *Honor and Country,* there should be written in letters of bronze, *It is the most stubborn who wins.*

XVI.

Physical Factors.

Speed.—You often hear it said, as a commonplace, that speed is a strategical quality, but that in tactics it counts for nothing. Yet it can force an enemy to fight who would endeavor to escape; it will facilitate the shifting of forces, will give vigor to attack; finally, it will make pursuit possible. It is, therefore, a tactical element.

It is also said that speed is a weapon. If speed is a weapon, its development will make up for inferiority of armament; and the *Guichen* can fight with the *Deutschland*.[57] We can hardly admit this.[58]

Speed is not a weapon; but, other things being equal, it facilitates the use of weapons. It will be profited by, therefore, the case occurring, in the same way as advantage is derived from the sun and the sea; an element that is only an auxiliary to weapons cannot be substituted for them. Speed, in fact, does not procure an unmixed happiness; it weighs heavily and costs dear.

It weighs heavily; therefore, it diminishes the number of weapons or their power; it weakens.

It costs dear; therefore, it cuts into financial resources; it reduces the number of units.

Speed may be the principal element in scouts that are not built with a view to fighting, or in torpedo-boats in which it is intimately connected with the employment of the torpedo; but in

[57] I refer to the old *Deutschland*.

[58] The *Guichen:* 8277 tons; two 6.5-inch and six 5.5-inch guns; no armor belt. The *Deutschland:* 7800 tons; seven 10.3-inch, six 5.9-inch and nine 4.7-inch guns; a complete belt.

Speed could, to a certain extent, supplement an inferior armament, if it allowed holding the enemy in a position that would prevent his using all his means. But it diminishes notably maneuvering qualities on account of the long distances it requires. So that a slow ship will perhaps not be able to put its faster adversary in a bad position, but will always be sure of presenting to the latter its best equipped sector of fire, which will assure to it superiority.

fighting ships it ought to be subordinated to the destructive power that is the *raison d'être* of the ship.

Some writers have appealed to the authority of Suffren in support of the development of speed in our ships. They have neglected to say that Suffren never called for a reduction of battery to increase the sail area; he merely asked that vessels be copper-sheathed, which would add to their sailing qualities without reducing their military strength.[59] To-day a comparison between the *Suffren* and the *Jeanne d'Arc,* both built for fighting, shows what speed costs.

By seeking absolute superiority of speed we shall only add to our numerical inferiority an inferiority of strength, and all the resources of strategy will not succeed in bringing us onto the battlefield with favorable chances of success. It will be necessary to take flight, to traverse the seas without hope. What a depressing doctrine!

It is not even safe to count upon speed for escaping. The battle of Santiago has shown us the uncertainty of speed. The machinery of a fast ship is not a faithful servant in whom one can confide; it is rather a capricious mistress whose infidelities are frequent. Whoever shall be in the necessity of trusting to it the destinies of the flag will pass through all stages of anguish. Quite otherwise will be the state of mind of the commander of a ship on which guns take the place of speed; he will derive confidence from the knowledge of his strength.

If we wish to profit by the advantages of speed and to have fast ships, we must not put horse-power in the place of guns. We must seek a solution that costs neither in weight nor in money, by calling upon the national genius to perfect the efficiency and improve the design of our motors.

While waiting, let us be content with the same speed as that of our rivals, since we know that in strategy an inferiority of speed may have grave consequences, and let us concern ourselves, above all else, with endurance.

Let us utilize speed to fight; let us not fight to utilize speed.

[59] See Suffren's report. The progress realized in the 18th century by the coppering of ships is of the same order as that which was realized in our time when the consumption of coal was reduced from 2 kilos to 700 grammes per horse-power per hour. But it must not be forgotten that gains of this sort are not monopolized by any one navy.

What is battle speed?

In principle, there would not seem to be any advantage in always moving at high speed; it would seem more reasonable to regulate speed according to the necessities of the moment, and to enter upon the battlefield at a moderate speed.

Nevertheless, practice demonstrates that in two-sided exercises the speed, at first moderate, is always increased progressively up to its maximum value. This fact results from the constant anxiety either to double the head of the enemy's line or not to be doubled by him. In one case as in the other, all one's resources are called for. Neither does it appear that one is ever embarrassed by the speed, and an urgent need of slowing down is rarely felt.

Alterations of speed always resulting in causing losses of position in the line, it is better to go into action with a well-kept formation, and at maximum speed, rather than to gradually increase speed.

By maximum speed should be understood the greatest speed that permits all the units to keep their positions and to rectify them at need. For a squadron of battleships of *Patrie* type, it would therefore be between 15 and 16 knots.

Homogeneity.—We have seen that in strategy homogeneousness, which gives the maximum efficiency to an assemblage of ships, is characterized by uniformity of speed and of radius of action. In tactics, in addition to speed, which we will not further discuss, we find a new element of homogeneity which is similarity of turning circles.[60]

Just as the speed of a fleet is that of its slowest ship, so its turning circle is that of the ship that has the greatest.

It is easily understood that in a navy like ours ships have a speed and armament dependent upon the period of their launchings; it is more difficult to justify immense differences in maneuvering qualities. There is no doubt, however, that the latter play a great part in battle. It would suffice to oppose a squadron of small turning circle to another less well endowed to become con-

[60] Uniformity of armament does not constitute a tactical advantage. There is more profit in having the most powerful guns, that is to say the most modern. The benefit of homogeneity of armament only appears after the battle, when it becomes a question of repairing and resupplying the ships.

vinced that the second will never be able to counter to the first's attacks because it will always arrive too late. Good maneuvering qualities are perhaps the best actual means that one can possess for getting the better of the enemy. It is therefore dangerous to disregard the value of homogeneousness by coupling together dissimilar vessels, which takes away from the mass the qualities of the various units.

Nautical Qualities.—To fire guns and launch torpedoes without regard (within reasonable limits) to the state of the sea; to have a steadiness of platform that increases the accuracy of fire: such are the two nautical qualities indispensable for a fighting ship.

Fighting will take place where it can, not where one would wish. Neither the time nor the weather will be subject to choice; they will be as happens. These two aphorisms are not absolute truths, since war does not allow of such; but we may say that the field of operations is enlarged when one is able to go in search of the enemy, wherever he may be, and to be independent of weather conditions. A turret that is too low will have its magazines flooded with water; a vessel that rolls 18° each way will be reduced to impotency. It is therefore necessary to attribute to the rolling and to the disposition of the guns an importance that has long been disregarded.

CONCLUSION.

We can sum up in two words: assimilate means to the end. Know what is wanted; pursue its realization with determination.

Naval war gives rise to two distinct problems. We can seek to look beyond the veil of the future and, when we have succeeded in creating for ourselves a doctrine, to forge weapons with which to put it into practice; or we can study the same question from an opposite point of view, and seek the best utilization of the weapons we have. This latter problem will arise when war breaks out; on that day regrets and recriminations will no longer avail; we will have to be content with what we have. It is nevertheless true that means ill suited to the conditions of war will singularly complicate its difficulties; and so long as peace lasts it is our duty to inquire in what way fighting will be carried on so that we may demand the necessary weapons. That is the sole chance of safety for a navy inferior in numbers; it is the best return for the sacrifices of money made by the nation.

Well, nowhere do we find precise rules that can serve us for guidance. The method generally adopted in the study of naval warfare doubtless contributes towards such a state of affairs. People insist upon asserting that war on the sea is a science, and, setting out from that principle, they treat it mathematically, dividing it up into an infinity of small problems without any connecting bonds. In order to arrive at giving to the diverse operations that are considered a form appropriate to the mold that is imposed upon them, the domain of convention is entered upon, and its true character is thus taken away from war. Moreover, the procedure being defective, nothing is learned from it. Despite the denials of those who would have war expressed by an equation, it is, has been and will remain an art, on land as well as on the sea.

Whatever may be the science necessary to give to ordnance its ballistic qualities, the action of pointing a gun on a moving platform at a target in motion can never be anything but an artistic manifestation. In the conduct of the fire, the art of the gunnery officer is felt, and the skill of which he gives proof has no science in it. All the products of modern science under the most various forms can be accumulated on board, and there will be needed none the less, to control the ship, a commander endowed with that artistic feeling that is called the seaman's sense. Finally, to lead a squadron under fire, the chief must judge the situation at a single glance, determine the advantage to be derived from it and the chances it offers: all of which is art. The scientific side of war manifests itself in the construction and equipment of ships, which, in fact, demand a greater and greater amount of science; but there is nothing to show that the qualities that are indispensable for forging a weapon are the same as those that should be possessed by the one who is to handle it.

Many people contend for the absence of all principle by saying that command ought to be left wholly free and its liberty of action not encroached upon. Everybody is in agreement on this point; but a precise regulation must not be confounded with the application of general rules. The laws of war cannot be a hindrance, for they are immutable and no one can transgress them with impunity. That which varies to an infinite extent is not the laws but the fashion of applying them that depends upon circumstances. The conceptions of command on the battlefield are only an appli-

cation, appropriate to a particular case, of fixed rules. The tactics that serves to put them into effect is common to all; it requires long practice and constant exercise, and that makes it necessary to prepare it in advance. Well, on what foundation can a tactics be built if there are no well-defined principles available?

The diversity of opinions, consequence of the uncertainty of our doctrines, is revealed by a certain uneasy feeling that a brutal fact brings still more clearly out: there is no new ship that is not the subject of numerous changes. It would be unjust to put the blame of this on the constructors. Is its explanation not to be found in the fact that we are unable to define exactly what we want, as well as the conditions that each organ of a ship ought to fulfil? Whence the constructors, left to their own inspirations, adopt the solution that seems to them reasonable without knowing its consequences. Thus they enter directly into the domain of the combatants by imposing their ideas upon the latter, while the sea-going corps, not finding what it wants, makes itself ridiculous by the diversion of designing ships. Such is the secret of that complication which makes the unenviable originality of our fleet; such is the reason of the fragility of our mechanisms; such particularly is the origin of the multiplicity of types.

We do not assert that it is only in France that things do not go as they should. Yet one thing strikes us: it is that we find in other navies a method that we vainly seek for in our own. England and Germany, for example, have pursued the realization of their particular objectives with more or less success, but with a tenacity to which we should render homage.

England, through her multiple interests, has in view the dominion of the seas; she has numerical superiority. For her, strategy is of greater importance than tactics: the English fleet is strategic.

Germany, on the contrary, is waiting to attain her development before pretending to anything more than the maintenance of the honor of her flag on the sea. She, therefore, limits her fields of operations to a restricted zone and develops the power of her not numerous units: the German fleet is tactical.

Here are two well-defined lines of conduct; the future will say whether they lead to the goal.

If we seek now to define the character of our fleet, we see that it is clearly defensive, in the sense that we find everywhere solici-

tude to ward off the enemy's blows instead of to seek to strike him. Some wish to shelter themselves behind immense walls of armor; others run like hares. Is that war? Can we not find a better use for our resources? Such are the problems that force themselves upon the minds of officers with an almost painful persistency. We have not pretended to solve them; we have simply discussed the means at our disposal, asking guidance of the past. Doubtless we have made mistakes. What matters it? Others will come, more competent and also of more authority, who will correct the errors and end by determining the true laws of war.

APPENDIX.

The Tactics of Torpedo-Boats.

Torpedo-boats are special vessels whose characteristic is that their attack does not deprive the enemy of his means of defence. This peculiarity influences their tactics, which is wholly based on surprise. Darkness and speed are its principal factors.

Theoretically, the attack of a torpedo-boat comprises three distinct phases: the getting into touch, the maneuvering for position, finally the launching of the torpedo.

As it will be night for the torpedo-boats as well as for the other vessels, the view of the former will never extend very far, and a lucky chance alone can bring about the contact. Thus, whenever the enemy has to be looked for in an extensive area, failures are frequent. To make a meeting certain, the field of investigation has to be reduced to limits that deprive the exercises of a part of their verisimilitude.

Let us admit a fortunate occurrence: the enemy is perceived in the shape of a dark mass. The first care of the torpedo-boat is to approach so as to ascertain the direction followed by its objective; then, when that is done, it will draw off, without losing touch, however, so as to place itself in a position favorable for firing.

This succession of operations is very simple to define and very difficult to accomplish. In fact, the first condition to fulfil is to avoid being discovered so as not to lose the advantage of the surprise that alone can assure the success of an attack. Well, within what limits can one see without being seen?[61] Then, to draw away, it is necessary to maneuver within sight, otherwise one does not himself see; in order not to risk losing touch, there is a tendency to approach during the whole time of maneuvering, which risks revealing one's presence while not in position to attack. Add that one's speed is high, that scarcely is the enemy seen when one is already right on him, that no conclu-

[61] Has an effort been made to determine the width of the neutral zone in which a torpedo-boat sees without being seen?

sion can be drawn from the ratio of speeds because that ratio is unknown, and a faint idea may be formed of the width of the chasm that separates the theory from practice. Thus, unless the enemy is somewhat obliging, this second phase of the attack only affords chances of success when the taking contact occurs in a position favorable for firing.

For the second time, let us suppose that this is so: it remains to launch the torpedo.

The sighting apparatus, which has been constructed with a view to day firings,[62] can only be utilized at night on condition that the torpedo-boats have been supplied in advance with data which they cannot determine at night. By what method estimate the speed and course of a shapeless mass that can scarcely be seen? All that can be done is to steer so as to draw near, without seeking to estimate an inappreciable distance, without paying any attention to the quarter from which the objective is approached; then to fire at the forward part of the target, if it has been possible to determine which way it is moving. But there comes a moment when the torpedo-boat is discovered and illuminated by a

[62] The principle of the sighting apparatus is correct; the application made of it is false. The data of the problem are: Speed of target, its course, speed of torpedo. Knowing two sides and included angle, it is always possible to construct a triangle; but in the case that concerns us an arbitrary value is assigned to two of the three data, and the accuracy of the process is thus reduced to nothing.

Since, whatever the system (and others can be imagined), there will always be unknown quantities, this would be as good as any if it had not brought about an increase of firing distance to the detriment of accuracy of fire. In fact, in enumerating the three elements of the triangle, it was seen that the angle of fire is independent of the distance; and everyone has been congratulating himself on having a firing method that permits increasing the range in proportion as the radius of action of the torpedo is increased. The most pleased, however, is the enemy, who is much less likely to be hit at 800 than at 400 meters, since the error made in the speed and course of the target is not independent of the range; it has no fixed value, but increases very rapidly in proportion as the firing distance increases.

Before thinking of increasing the firing distance, the speed of the torpedo should first be raised to a figure such as to make the error in speed and course of target negligible. The torpedo will then be a projectile of low initial velocity and horizontal trajectory. Until then all increase of speed must be taken advantage of without changing the firing distance. This applies solely to torpedoes fired from torpedo-boats; the problem is quite a different one for big ships.

searchlight; thenceforth it is blind, it perceives nothing more but a luminous shaft that dazzles it, ... and it fires badly.[63]

The difficulties that are encountered in the realization of the three phases of attack suffice to explain the great number of failures to which exercises give rise. Yet these occur under more favorable conditions than in time of war on account of the precautions that it is necessary to take to avoid the accidents that happen when they are neglected. In any event it is certain that the torpedo-boat's maneuvers, as they are laid down in certain treatises, are purely conventional. So long as this sort of vessel has to count on the assistance of darkness, it will be self-condemned not to see, and in that case maneuvers cannot be expected of it that, from their rigorous precision, require mathematical data.

Without doubt the efficiency of the torpedo-boat will always be small; but it would be wrong to feel astonished at this, since it compares favorably in this respect with other weapons. Has it been forgotten that at Santiago the efficiency of the gun was less than 3 per cent? It is irritating to think that the majority of torpedo-boats get within range of the enemy without hitting him; it is always imagined that new weapons possess an infallibility that the old ones lacked, because we do not have for the former the same means of appreciation as for the latter. Unfortunately, up to the present, the advantages of weapons have always been compensated by the disadvantages to which they gave rise, and in time of peace we naturally only give importance to the advantages.

The best method of increasing the value of torpedo-boats is to make them act in mass. The effects of a group attack are not

[63] For a target in motion, the tube with train would, therefore, appear preferable to the fixed tube; but it is then necessary to divide the duties in order to simplify each one's rôle, the captain directing the boat, the second officer or leading man taking care of the firing of the torpedo. Each one will thus have duties sufficient to take all one man's attention, and it would compromise the result to confide them all to a single person. The commanders of torpedo-boats won't be pleased to give up ordering *fire*, that being a privilege that is dear to them. But what is primarily important is to sink the enemy and to use the best method of attaining that end. Well, it was shown by systematic exercises carried out in the Mediterranean squadron some years ago that officers who try at the same time to direct the boat and watch for the moment to fire throw away more torpedoes than those who prefer to do less but do it better.

merely proportional to the number of units: each boat lends support to the rest by helping to multiply the objectives and turning upon itself a part of the enemy's fire. The pointer of a rapid-fire gun who holds a torpedo-boat at the end of his line of sight will never let it go; he will keep on firing at it furiously so long as a piece of its hull is afloat, and meanwhile he will pay no attention to others. When a boat is discovered and fires its torpedo, it concentrates on itself the attention of the whole ship; the crews of guns that are unable to fire cannot keep their attention off an occurrence upon which the fate of the ship depends; instinctively everyone wishes to see.[64] Then the torpedo-boats of the group that have not been perceived will take advantage of this situation; they will debouch so as to avoid putting themselves in the rays from the searchlights and will draw away from the boats that are illuminated; they will even seek, if conditions are favorable, to attack on the opposite side, guided by the blaze of the searchlights to determine the enemy's position.

In an attack in group, the maneuver of each torpedo-boat cannot, therefore, be laid down in advance. It depends on circumstances, on the way in which the searchlights are directed, on the number and position of the boats that are lighted up, on the enemy's movements. It differs radically from those methodic and geometric attacks that, under the name of simulated attacks, seem to embody the tactics of torpedo-boats, and whose progression ends with the final apotheosis of the attack in fan-shaped formation.[65]

In the attack in mass, the leading torpedo-boats are sacrificed. It is an assault and the first who mount into the breech have few chances of returning unharmed. If the enemy is attacked by torpedo-boats singly, each of them will run as many risks as the first boat of a group.

[64] The impression that the sudden appearance of a torpedo-boat causes is such that, in time of peace when there was no real danger, guns have been seen fired on the side away from the attack when the men on watch have given the alarm.

[65] Exercises, those of torpedo-boats as well as of other vessels, will have a fictitious basis so long as it is desired to prescribe in advance the line of conduct that each must follow and so long as there is refusal to admit that, on the field, it is necessary above all to draw inspiration from the situation and to maneuver in accordance with broad principles rather that according to narrow rules.

The Russo-Japanese War has given us the measure of what could be expected of torpedo-boats. The bravery of the sailors being beyond question, it is the weapon itself that we must hold responsible for the insignificant results obtained; and we are obliged to confess that the efficiency was much inferior to what had been counted upon. Yet the torpedo-boats were constantly to the fore; they had a thousand opportunities to make good. The battle of Tsushima was needed to rehabilitate them, but it ought not to be lost sight of that their action was favored by the artillery contest that preceded the night attack and had deprived the remnants of the Russian squadron of a part of its means of defence.

We will not draw from this any conclusion unfavorable to torpedo-boats. We will merely say that it is wrong to consider that their action should be independent of that of the battleships. The two actions, instead of being necessarily simultaneous, would on the contrary gain by being carried on successively, the attack of the torpedo-boats being prepared by the ships' batteries just as, on land, infantry is supported by artillery.

The aid that the battleships are able to furnish to torpedo-boats is sufficiently effective for day attacks not to be repudiated *a priori*. In such an event it would be possible to place the torpedo-boats in groups abreast the head and rear of the battleships, on the side away from the enemy and out of range of his guns. The forward group would thus be in good position to attack when the slackening of the fire permitted; the rear group would throw itself upon injured ships that have been obliged to drop astern.

Finally, there is a third eventuality that must be faced. There are situations in war in which there must be no hesitation to sacrifice a part of one's forces to save the rest. In such a case, whether conditions are more or less favorable ceases to be a matter for consideration; it is necessary before all else to do what is most urgent. If an admiral believes that by sacrificing his torpedo-boats at the very beginning of the action, to stop a leading ship, for example, he will assure winning the day or will retrieve a dangerous situation, he ought not let himself be stopped by sentimental considerations. Unhappily, success alone can justify holocausts; since, if one fails, good reasons to explain one's conduct are lacking. Public opinion is easily influenced against an unsuccessful maneuver that would have been found to be a stroke of genius if it had succeeded. That is why there is often hesitation to employ decisive methods.

In closing, we will observe that, when torpedo-boats have an objective that is known to be in a determined zone, they ought always to take in in reverse; that is to say, they should always make their attack from the side where it is least to be expected. In reality all sectors of the horizon are equally dangerous when no material obstacles exist to stop the torpedo-boats; nevertheless, a squadron that is blockading a port will watch more closely the landward than the seaward side, and the opposite would be the case for a ship at anchor. There is an irresistible tendency to take the greater precautions in the direction which is reasonable, even though knowing that it is to the enemy's interest not to come that way. One thus has at least the satisfaction of having done all that is possible when means for opposing all dangers are wanting. The worst that can happen to torpedo-boats attacking in reverse is to find the enemy equally guarded on all sides.

The Japanese furnished us with a proof of this when their squadron escorted the convoy that was to operate against Wei-hai-Wei. In prevision of a possible attack by Chinese torpedo-boats coming from that port, Admiral Ito placed his fighting ships on the flank of the transports and on the side towards Wei-hai-Wei. Evidently there was no reason, on this occasion, to attribute to the Chinese any deep-laid plans; yet the attack might have taken place on the opposite side, or from ahead, without premeditation, on account of the uncertainty that always exists as to the point of meeting.

In case of blockade, the torpedo-boats ought not to be stationed in the blockaded port; for their operations would be complicated by the necessity of forcing a passage through the enemy destroyers. They ought to set out from a distant point, and even if their place of refuge is known their situation is better because they compel the enemy to watch two points instead of one.

Theoretically, the most favorable hour for an attack is the end of the night; attention relaxes little by little and the men on watch end by becoming persuaded that this time again nothing will happen. Practically, one hour is as good as another: since it is never easy to meet the enemy, it is necessary to take the time to seek him and to attack him where he has been found, in order not to risk missing him.

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A NOMOGRAM FOR COMPASS DEVIATIONS, WITH AN ELEMENTARY EXPOSITION OF THE TWO PARALLEL SCALE NOMOGRAMS.

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Translated from the original manuscript by
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§1. Among the various types of nomograms that can be constructed by means of the fertile and genial method of alined numbered points,[1] the one having the greatest number of applications is, undoubtedly, that having two parallel rectilinear scales.

It seems to us that many more useful applications would appear if the study of the principle upon which it is based did not constitute a great difficulty for those who do not know or do not remember the principles of *Analytical Geometry;* and this is true when we notice that the principle is, generally, explained by referring to a special system of parallel co-ordinates instead of the ordinary system of Cartesian co-ordinates.

In this short note we propose to show how with a knowledge of *Elementary Mathematics* (in which the definition of function is comprised in order to facilitate our explanation) it is possible to understand and use the above mentioned principle.

It will then be possible for all to appreciate the advantages of the modern methods and possibly lead to surmounting the difficulties met in the fundamental study of modern *nomography.*

§2. If we have an equation between four variables, α, β, γ, δ; if this equation can take the following form

$$\phi(\alpha)f_1(\gamma,\delta)+\psi(\beta)f_2(\gamma,\delta)+f_3(\gamma,\delta)=0 \qquad (1)$$

[1] D'Ocagne: *Traité de Nomographie* (Gauthier-Villars, Paris, 1899, page 123); *Le Calcul Simplifié* (Bibliothèque générale des Sciences, Gauthier-Villars, 1905, page 177); *Calcul graphique et Nomographie* (Encyclopédie scientifique, Doin, Paris, 1908, page 221).

(where $\phi(\alpha), \phi(\beta), f_1(\gamma, \delta), f_2(\gamma, \delta), f_3(\gamma, \delta)$ are functions of the variables respectively indicated) we can construct a nomogram[2] with two parallel scales that will give one of the variables when the other three are known.

There are many practical examples of equations that satisfy these conditions. Here are some that we have already considered ourselves. We will place between brackets the expressions that correspond to $\phi(\alpha)$ and $\psi(\beta)$ and alongside of them also between brackets the two variables that correspond to γ and δ.

$$[\tan \delta] r' + \left[\frac{2}{\text{arc } 1'} \sin^2 \frac{P}{2} \right] - r' \tan \phi_a = 0, \quad [r' \phi_a] ; \qquad \text{(I)}$$

used in *Nautical Astronomy* to calculate the latitude $\phi = \phi_a - r'$, from a circummeridian altitude.[3]

$$[\tan \epsilon] V^2 + [V^2{}_a] \tan \phi_1 - V^2 \tan \phi_1 = 0, \quad [V, \phi_1], \qquad \text{(II)}$$

used in *Ballistics* to calculate the initial velocity V.[4]

$$[E] A + [i] 2d - (1 - 2a) d^2 - 2h_1 d = 0, \quad [d, h_1], \qquad \text{(III)}$$

used in *Terrestrial Navigation* to find the distance between a ship and an object at sea.[5]

$$[n] \sin(\alpha + \omega) + [m] \sin \omega - \sin \alpha = 0, \quad [\alpha, \omega], \qquad \text{(IV)}$$

which appears in the solution of an important problem of *Naval Tactics*.[6]

$$\rho = \frac{d}{k+1} e^{\frac{\omega}{\sqrt{k^2-1}}} \qquad \text{(V)}$$

[2] Of that type of nomogram we present a simple application; see for ex., Deville, *Abacus of the Altitude and Azimuth of the Pole Star* (Transactions of the Royal Society of Canada, 1906).

[3] *Abbaco per il calcolo della latitudine mediante un altezza circummeridiana,* Rivista Marittima, October, 1898.

[4] *Cenni di Nomografia,* II Edizoni, Giusti, Livorno, 1910, page 45.

[5] *Sul calcolo delle distanze in mare,* Nota I, Rivista Marittima, July, 1897. In the nomogram the dip scale i was replaced by the scale of heights of the eye e; thus, given e, E (difference between the height of the observed object and of the eye of the observer) and hi (observed angular altitude) we will find immediately the distance d. This distance is already corrected for the error due to geodetic refraction, without its being necessary to find beforehand an approximate value (FAYE: *Cours d'Astronomie Nautique,* Paris, Gauthier-Villars, 1880, page 361).

[6] *Quarto contributo alla Cinematica navale,* Rivista Marittima, January-March, 1898. It is a very remarkable problem developed by Admiral Courbet, Captain Vidal (repeatedly), Captain Vivier and Lieutenant Tournier.

which can be given the following form:

$$[\omega]\frac{1}{\sqrt{k^2-1}}+[\log_e d]-\log_e(k+1)-\log_e\rho=0,\ [k,\rho],\quad (V')$$

which appears in *Naval Strategy* to draw the curve of research proposed by *Montechant.*[7]

§3. Let us take on two parallel straight lines, p and q, two points, P and Q, as the origin, the arrows showing the positive direction.

Giving to α and β a series of values (generally in arithmetical progression), we calculate the corresponding values of $\phi(\alpha)$ and of $\psi(\beta)$ and indicating by l and h two arbitrary coefficients, we place these successive values on the lines p and q.

$$PA_i=l\phi(\alpha_i),\qquad (2)$$

$$QB_i=h\psi(\beta_i),\qquad (3)$$

with care to assign the points with the corresponding values of α on β. This value is called the number of the point, and we call *scale* (α) or *scale* (β), the numbered points placed respectively on the lines p and q.

Let A_1 and A_2 be two points of the scale (α) and B_1 and B_2 two points of the scale (β); let us join A_1 and B_1 and B_2 and A_2 and give to the intersection C two numbers γ and δ equal to the values of γ and δ that satisfy the system of equations

$$\left.\begin{aligned}\phi(\alpha_1)f_1(\gamma,\delta)+\psi(\beta_1)f_2(\gamma,\delta)+f_3(\gamma,\delta)=0\\ \phi(\alpha_2)f_1(\gamma,\delta)+\psi(\beta_2)f_2(\gamma,\delta)+f_3(\gamma,\delta)=0.\end{aligned}\right\}\qquad (4)$$

If we consider now two other points, A_3 and B_3, we want to demonstrate that if *the straight line* A_3B_3 *passes through* C, *the four values* α_3, β_3, γ and δ satisfy equation (1) and reciprocally.

If A_3B_3 passes through C, we have

$$\frac{A_1A_2}{B_1B_2}=\frac{A_1A_3}{B_1B_3}\qquad (5)$$

or

$$\frac{PA_2-PA_1}{QB_2-QB_1}=\frac{PA_3-PA_1}{QB_3-QB_1}\qquad (6)$$

or by means of (2) and (3)

$$\frac{\phi(\alpha_2)-\phi(\alpha_1)}{\psi(\beta_2)-\psi(\beta_1)}=\frac{\phi(\alpha_3)-\phi(\alpha_1)}{\psi(\beta_3)-\psi(\beta_1)};\qquad (7)$$

[7] *Sulla costruzione della curva de ricerca,* Rivista Marittima, December, 1896.

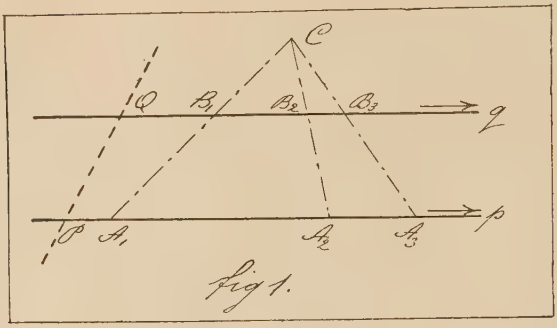


fig 1.

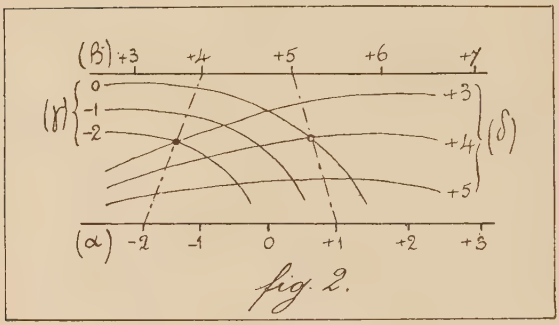


fig. 2.

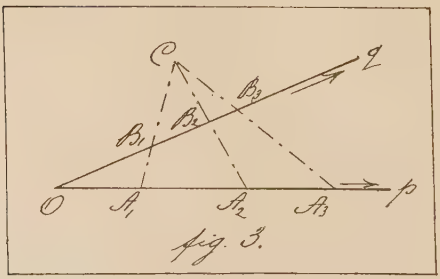


fig. 3.

but from (4) we have

$$\frac{\phi(\alpha_2)-\phi(\alpha_1)}{\psi(\beta_2)-\psi(\beta_1)}=-\frac{f_2(\gamma,\delta)}{f_1(\gamma,\delta)}; \tag{8}$$

thence, from (7),

$$\frac{\phi(\alpha_3)-\phi(\alpha_1)}{\psi(\beta_3)-\psi(\beta_1)}=-\frac{f_2(\gamma,\delta)}{f_1(\gamma,\delta)}; \tag{9}$$

and, taking into consideration the first equation of group (4), we have

$$\phi(\alpha_3)f_1(\gamma,\delta)+\psi(\beta_3)f_2(\gamma,\delta)+f_3(\gamma,\delta)=0. \tag{10}$$

Reciprocally, if (4) and (10) are satisfied, (7) is true, from which we have (6) and afterward (5), and therefore the line A_3B_3 passes through the intersection of A_1B_1 and A_2B_2.

Observation.—It may happen that to two or more values of α correspond the same value of $\phi(\alpha)$: the same point of scale (α) will have then two or more different numbers. The same may be said about scale (β).

§4. Given equation (1), all points of the plane (of the paper) will therefore have two numbers γ and δ determined by the system of equations (4) when A_1B_1 and A_2B_2 are two straight lines passing through the particular point (γ,δ) considered. Let us imagine that we have drawn all the curves, each one of which passes through all the points numbered γ and δ, we will have two *systems* of curves (γ) and (δ), Fig. 2, which, together with the scales (α) and (β), will permit the immediate solution of equation (1).

Thus, given α; β and γ (the same proceedings if α, β and δ were given) we join A numbered α with B numbered β; this line will cut the curve numbered γ in a point C through which a curve numbered δ also passes; the number of this curve will be the number that together with α, β and γ satisfies (1). Given α, γ and δ (the same proceedings if β, γ and δ were given), we join A numbered α with C numbered γ and δ; this line will cut scale (β) in B; the number of this point will be the value of β that together with the three values given, α, γ and δ, satisfy equation (1).

Thus, in Fig. 2 (considering only the existing curves drawn),

for $\alpha=-2, \beta=+4, \gamma=-2$, we have $\delta=+3$,
for $\alpha=+1, \gamma=0, \quad \delta=+4$, we have $\beta=+5$.

Observation I.—According to the observation of the preceding §, we notice that the same curve γ or δ can have two or more numbers.

Observation II.—We have supposed that the line AB intersects the curve numbered γ in one point only; if it intersects in more than one point, the numbers of the curves (δ) passing through that point are other solutions of (1).

Observation III.—With (1) we can construct very easily a nomogram with concurring rectilinear scales.

In Fig. 3 we have

$$OA_i = \frac{l}{\phi(\alpha_i)} \text{ and } OB_i = \frac{h}{\psi(\beta_i)},$$

instead of (5) we have now

$$\frac{A_1A_2}{B_1B_2} \cdot \frac{OB_2}{OA_2} = \frac{A_1A_3}{B_1B_3} \cdot \frac{OB_3}{OA_3}$$

from which we have easily (7). For this type of nomogram (to which we only call attention on account of being very seldom used) we could repeat what we have said heretofore regarding the other type.

§5. In the preceding § we supposed that once taken the values α_1, β_1 and α_2, β_2 by the system of equations (4) we can always find the corresponding values of γ and δ of point C.

This hypothesis is very frequently met with in practice; ex., all the five cases mentioned in §2; in two other cases shown in the general nomogram of *Spherical Trigonometry* and that of *Plane Trigonometry;*[8] also in all examples that have come to our knowledge. It might have happened that the system (4) could not be solved, or being capable of solution, the necessary operations would be too complicated, as happens in the last two of the five examples given. This impossibility or this difficulty disappear completely, if the following process is used instead:

Required point C numbered γ, δ. We calculate in the first place $f_1(\gamma, \delta)$, $f_2(\gamma, \delta)$, $f_3(\gamma, \delta)$; and afterwards we give to α two arbitrary values α_1, α_2, and we calculate $\phi(\alpha_1)$, $\phi(\alpha_2)$; then by means of (1) we calculate the corresponding values of $\psi(\beta_1)$, $\psi(\beta_2)$; finally, by means of (2) and (3), we find the corresponding points A_1, A_2 and B_1, B_2: the intersection of A_1B_1 and A_2B_2 will be the

[8] The first one was constructed by d'Ocagne (*Tr. de Nomographie,* page 331), the second by ourselves (*Abbachi trigonometrici,* Periodico di Matematica, March, 1900); and it was precisely for the construction of these two nomograms that we explained, for the first time, the simple process of §4 (*Costruzione elementare di due abbachi trigonometrici,* Supplemento al Periodico di Matemica, April, 1900).

point C required. It is very important to notice that it is not necessary to know the values of β_1, β_2 (which might not be possible), but it is enough to know the values of $\psi(\beta_1)$ and $\psi(\beta_2)$. We notice also that instead of giving two arbitrary values to α, we could have given two arbitrary values to β, or (as it is sometimes convenient to do) we could give one to α and another to β.

In ordinary cases it is easy to select these values in such a way that the calculation presents remarkable simplifications. Thus in ex. II (§2) for $V_a=0$ we have $\epsilon=\phi_1$, and for $\epsilon=0$ we have $V_a=V$; it is sufficient to aline the origin of scale (V_a) with the numbered point ϕ_1 of scale (ϵ) and the origin of scale (ϵ) with the numbered point V of scale V_a in order to have the point numbered V, ϕ_1. Thus in ex. (V) we have for $\omega=0$, $d=(k+1)\rho$, and for $d=1$, $\omega=(\log(k+1)+\log_e\rho)\sqrt{k^2-1}$; when ρ and k are given we can have d in the first case, ω in the second by the same process.

In practice the values of α and β considered are generally comprised between given limits and generally γ and δ are also correspondingly comprised between certain limits.

As we select for α and β a series of values in arithmetical progression comprised between certain limits, we also do the same for γ and δ; thus, for each value of γ we give δ all the values considered and we draw lines through all the points numbered γ, obtaining in this way all the curves (γ); also we find all the points of the curves (γ) that have the same number δ and in this way we obtain all the curves (δ). Of each curve we have a series of isolated points, but we can find them near enough one another to enable us to draw the curve with sufficient approximation.

In this way we would construct the nomogram corresponding to ex. (IV), in which we calculate very easily the values of n and m corresponding to $m=0$ and $n=0$ respectively.

The other four examples present remarkable simplifications which we will mention now.

Observation.—For each one of the four variables we have considered only a series of values in arithmetical progression, and then it will be necessary to make a visual interpolation which, with three independent variables, is much easier than the ordinary numerical interpolation would have been.

§6. From what we have said we see how with the sole knowledge of *Elementary Mathematics* it is always possible to construct theoretically by means of (1) a nomogram of the type indicated;

we say *theoretically,* however, because *in practice* many difficulties may present themselves which cannot be surmounted,—not even with a knowledge of *Higher Mathematics.*

These difficulties are of two kinds: it may happen that corresponding to the values of α and β considered, it is not possible to comprise all the corresponding points A, B and C in a drawing of limited dimensions; and it may happen that, although of limited dimensions, it would have to be too large in order to give sufficient approximation.

The second difficulty is generally not surmountable (thus, for ex., the nomogram of *Spherical Trigonometry* referred to cannot solve with sufficient approximation the *general* problems of *Nautical Astronomy*); there are, however, a great number of applications in which this inconvenience does not present itself.

And it ought to be so, because a nomogram is finally a graphic solution (that answers all cases, and is done once for all), and in many practical cases the solution gives sufficient approximation: proof of this is found in the ever increasing applications of *Graphical Statistics* both in number and in importance.

The first difficulty can sometimes be overcome by means of special artifices[9] or by proceedings of a general character, of which we will consider here two cases.

If $\phi(\alpha)$ and $\psi(\beta)$ tend to become infinite, without having, however, values near 0, we can use the type of nomogram considered in Obs. III of §4.

If any point C becomes very far away from the lines p and q (or if the lines A_1B_1 and A_2B_2 are parallel or too little convergent) the difficulty can be obviated and the useful part of the nomogram will be comprised between the two parallel scales when (for all the values of γ and δ that we have to consider) the two functions $f_1(\gamma, \delta)$ and $f_2(\gamma, \delta)$ have always the same sign. Thus, as

$$A_1A_2 = l[\phi(\alpha_2) - \phi(\alpha_1)], \quad B_1B_2 = h[\psi(\beta_2) - \psi(\beta_1)],$$

from (8) we have

$$\frac{A_1A_2}{B_1B_2} = -\frac{lf_2(\gamma, \delta)}{hf_1(\gamma, \delta)}, \tag{11}$$

which demonstrates that, if the signs of $f_1(\gamma, \delta)$ and of $f_2(\gamma, \delta)$

[9] An example is found in *Sur l'application de la Nomographie aux principales tables nautiques* (§V), by Lieutenant Perret, French Navy, presented to the Congress of Cherbourg, 1905.

are alike (which happens in all the examples of §2, excepting in part the fourth), the segments A_1A_2 and B_1B_2 (Fig. 1) are of contrary signs and therefore the intersection of the two lines A_1B_1 and A_2B_2 is certainly inside the space comprised between the two parallel scales; if, instead, the signs of $f_1(\gamma, \delta)$ and of $f_2(\gamma, \delta)$ are different (which happens for the general nomogram of *Spherical Trigonometry* and for the example given later on) it is sufficient to take

$$QB_i = -h\psi(\beta_i) \qquad (12)$$

instead of (3), changing then also the sign of $f_2(\gamma, \delta)$, because this will change the positive direction of the line q and it will fall in the preceding case. There will be an exchange between the two cases if the positive directions of the two lines p and q, instead of being turned in the same direction (as in Fig. 1) are turned one one way and one the other way.

It is, finally, important to observe that, if the condition mentioned above (regarding the signs of $f_1(\gamma, \delta)$ and $f_2(\gamma, \delta)$) is satisfied and if $\phi(\alpha)$ and $\psi(\beta)$ are comprised between finite limits, it is always possible to determine the coefficients h and l (§3) so that the nomogram will be comprised in a given trapezium or in a given rectangle.

Observation.—With slight modifications to what we have seen [10] we could construct a nomogram with two parallel scales also for an equation between three variables that can take the following form:

$$\phi(\alpha)f_1(\gamma) + \psi(\beta)f_2(\gamma) + f_3(\gamma) = 0.$$

§7. Generally it is only with a knowledge of *Analytical Geometry* that we can know *a priori* the forms of the lines (γ) and (δ); we see then promptly that all these lines are radii or a system of conics (because the problems that present themselves in practice are of the first or second degree mostly) and then we can draw them immediately, by the methods indicated in *Analytical Geometry,* and also by points. However, some cases present themselves in which by means of *Elementary Mathematics* alone we can see *a priori* that one of the two systems, or both, reduce themselves to radii. Here are some of the most common cases:

[10] *Sobre Nomografía Elemental* (Revista Trimestral de Matemáticas, Zaragosa, 1905), where, after the explanations of §5, we can introduce remarkable simplifications.

I. If (1) can be given the following form:

$$\phi(\alpha)f_1(\gamma,\delta)+\psi(\beta)f_2(\delta)+f_2(\delta)f_3(\gamma)=0, \qquad (13)$$

the system (γ) is a collection of straight lines with P as center; for $PA=0$, we have from (13)

$$QB=h\psi(\beta)=-hf_3(\gamma),$$

therefore all the points C having the same number, no matter what the other number δ, are alined with P.

If, as a particular case of (13), (1) can be given the following form

$$\phi(\alpha)f_1(\gamma)+\psi(\beta)f_2(\delta)+f_2(\delta)f_1(\gamma)=0, \qquad (14)$$

the system (δ) will also be a collection of straight lines and its center will be Q, because for $QB=0$ from (14) we have

$$PA=l\phi(\alpha)=-lf_2(\delta).$$

We have an example of this particular case in II of §2.

II. If (1) can take the form

$$\phi(\alpha)f_1(\gamma)+\psi(\beta)f_2(\gamma)+f_3(\gamma,\delta)=0, \qquad (15)$$

the system (γ) will be a collection of straight lines parallel to the two scales (α) and (β); in this case by means of (11)

$$\frac{A_1A_2}{B_1B_2}=-\frac{lf_2(\gamma)}{hf_1(\gamma)},$$

the relation depends only on γ and therefore for a given value of γ, whatever be the value of δ, the points C are on a line parallel to the lines A_1A_2 and B_1B_2. In order to draw all these lines it is sufficient to find a point C where the line numbered γ intersects the line PQ, and to do this we notice that we have

$$\frac{PC}{QC}=\frac{A_1A_2}{B_2B_1}=\frac{lf_2(\gamma)}{hf_1(\gamma)}, \text{ or } PC=PQ\cdot\frac{lf_2(\gamma)}{hf_1(\gamma)+lf_2(\gamma)} \qquad (16)$$

Examples of this case are those numbered III (where A is a constant) and V of §2.

If, as a particular case of (15), (1) takes the following form

$$\phi(\alpha)f_1(\gamma)+\psi(\beta)f_2(\gamma)+f_3(\delta)f_1(\gamma)=0, \qquad (17)$$

the system (δ) will also be a collection of straight lines with its center in Q, as results from what we have said regarding (14).

An example of this case is presented in I of the five examples mentioned.[11]

If, as another particular case of (15), (1) takes the following form

$$\phi(\alpha)f_1(\gamma)+\psi(\beta)f_2(\gamma)+\delta f_3(\gamma)=0, \qquad (18)$$

for $PA=0$ we have

$$QB=h\psi(\beta)=-\frac{h\delta f_3(\gamma)}{f_2(\gamma)}, \qquad (19)$$

where for a given value of γ, to equal increases of δ correspond equal increases of QB. From this we see that it is only necessary to draw two of the curves δ in order to obtain all the others; as the values of δ considered are in arithmetical progression, all the corresponding curves determine upon each line γ a series of points equally distant from one another. In the following § we will give an example.

If, as a particular case of (15), we can give (1) the following form

$$\phi(\alpha)f_1(\gamma)+\psi(\beta)f_2(\gamma)+f_3(\delta)=0 \qquad (20)$$

and if

$$hf_1(\gamma)+lf_2(\gamma)=\text{constant}, \qquad (20')$$

the system δ is also a collection of straight lines parallel to the lines PQ and also to the scales (α) and (β). Thus, if we take

$$PA=l\phi(\alpha)=-\frac{hlf_3(\delta)}{hf_1(\gamma)+lf_2(\gamma)},$$

we will have

$$QB=h\psi(\beta)=-\frac{hf_3(\delta)+hf_1(\gamma)\phi(\alpha)}{f_2(\gamma)}=l\phi(\alpha),$$

where, by means of (20') for each value of δ, whatever the value of γ, the corresponding points C are situated upon a line parallel to PQ. We have an example of this case in the nomogram of spherical distances.[12]

[11] We have given other examples in our two notes: *Application de la Nomographie au jaugeage des tonneaux*, Le Génie Civil, 1899; *Applicazione della Nomografia a un problema di Geometria Pratica*, Monitore Tecnico, 1900.

[12] *Tr. de Nomographie*, page 327. This nomogram, of which we gave a very elementary construction (Revista Maritima Brazileira, 1907-1908), might be annexed to the great geographical atlases because it gives immediately the spherical distance between any two points upon the surface of the globe.

Observation.—More generally, the system (δ) will be evidently a collection of straight lines parallel to PQ if the first member of ($2o'$) is a function of δ alone.

§8. We will put an end to our consideration with a new example.

Required the nomogram of the equation

$$U = B' \sin M + C' \cos M, \tag{21}$$

where U, B', C', M are all variable: under the form

$$B' \sin M - U + C' \cos M = 0,$$

it is of type (1) and supposing

$$\alpha = B', \ \beta = U, \ \gamma = M \text{ and } \delta = C',$$

where

$$\phi(\alpha) = B', \ \psi(\beta) = U, \ f_1(\gamma, \delta) = \sin M, \ f_2(\gamma, \delta) = -1, \ f_3(\gamma, \delta) = C' \cos M,$$

we have the particular case (18).

We begin by drawing the scales (§§3, 6)

$$PA = lB', \tag{22}$$

$$QB = -hU, \tag{23}$$

which can be immediately done, uniform as they are; the straight lines (γ) are drawn afterwards, observing that from (16) we have now

$$PC = PQ \frac{l}{h \sin M + l}. \tag{24}$$

The system of curves (C) can be drawn remembering that from (18) we have for $PA = 0$

$$QB = -hC' \cos M, \tag{25}$$

and therefore for a given value of C', if we make M vary and calculate all the corresponding values of QB, the lines passing through P and B determine on each line M a point C' of the curve; thus it is only necessary to draw two of these curves, for one of which we take the line PQ to which evidently reduces itself the curve $C' = 0$. We notice that (considering M variable only between 0° and 90°) we have an arc of each curve C' situated on one side of the line PQ; thus for $M = 0$ from (25) we have $QB = -hC'$; having in view (23) we see that the number of each one of these arcs is equal (in absolute value and in sign) to the number of the point in which the same arc intersects the scale (U).

In the large figure the line that passes through the origins of the two parallel scales is taken perpendicular to the same scales; further we have supposed that B' and U vary by 1° between $-20°$ and $+20°$, that C' varies by 2° between the same limits, that M varies by 10° between 0° and 90° and that PQ (or the distance between the two parallel scales (B') and (U) is equal to 10 cm. We have further supposed that the length of the parallel scales is equal to 20 cm., and for this reason we have taken $h=l=0.5$ cm. We can see that from (24) the lines (M) occupy now only the upper half of the rectangle and that from (25) all the arcs (C') have an extremity in the center of the rectangle.

We notice that this nomogram can be used for any value of M; thus if M_1 is the value of M reduced to the first quadrant, and according to the quadrant in which M ends we have

$$U=+B'\sin M_1-C'\cos M_1,\quad U=-B'\sin M_1-C'\cos M_1,\text{ or}$$
$$U=-B'\sin M_1+C'\cos M_1,$$

and therefore it is sufficient, respectively, to change the sign of C', change the signs of of B' and of C' and change the sign of B' in order to have U in the corresponding cases.

We notice, finally, that with the same nomogram we can find immediately also the values of R and the angle α' of the following formulæ:

$$R=\sqrt{B'^2+C'^2}, \tag{26}$$

$$\tan\alpha'=\frac{[B']}{[C']}, \tag{27}$$

where $[B']$ and $[C']$ are the absolute values of B' and C'. Thus from very elementary considerations we see that R is the absolute maximum value of U and that α' is the corresponding value of M: if we aline the numbered point $[B']$ of scale (B') with the numbered point $[C']$ of scale (U), we see that this line intersects the arc numbered $[C']$ in two points; turning this line to the left these two points approach each other until they coincide (the point where the line *touches* the arc is called then the *point of contact*); turning further the line it has no further contact or does not intersect the curve any more.

Thus it is evident that the maximum of U occurs when the line mentioned touches the arc $[C']$; therefore, to obtain R and α', given B' and C', it is only necessary to draw a line through $[B']$ of scale (B) touching the arc $[C']$ which will determine on scale

(U) the absolute maximum value of U and at the point of contact the corresponding value of M (reduced to the first quadrant) or the value of α'.

Observation I.—From what we have said we notice that the nomogram can be constructed very rapidly, because it is enough to perform the calculation of (24) for each of the values of M that we wish to consider and to do likewise with (25) when we give to C' the first value (different from zero) of the corresponding series.

Observation II.—From *Analytical Geometry* we know that the curves (C') constitute a system of parabolas, having all for axis the line PQ, for vertex the mean point of the segment PQ (supposing $h=l$) and for variable parameter $2C'^2$.

§9. This nomogram is useful in calculating the deviation δ of a compass.

Thus the approximate formula is [13]

$$\delta = A' + B' \sin M + C' \cos M + D' \sin 2M + E' \cos 2M, \quad (29)$$

and from the nomogram we can find immediately the semicircular deviation $B' \sin M + C' \cos M$, and the quadrantal deviation $D' \sin 2M + E' \cos 2M$.

Thus for

$$A' = +1°,\ B' = -10°,\ C' = -8°,\ D' = -6°,\ E' = +2°,$$

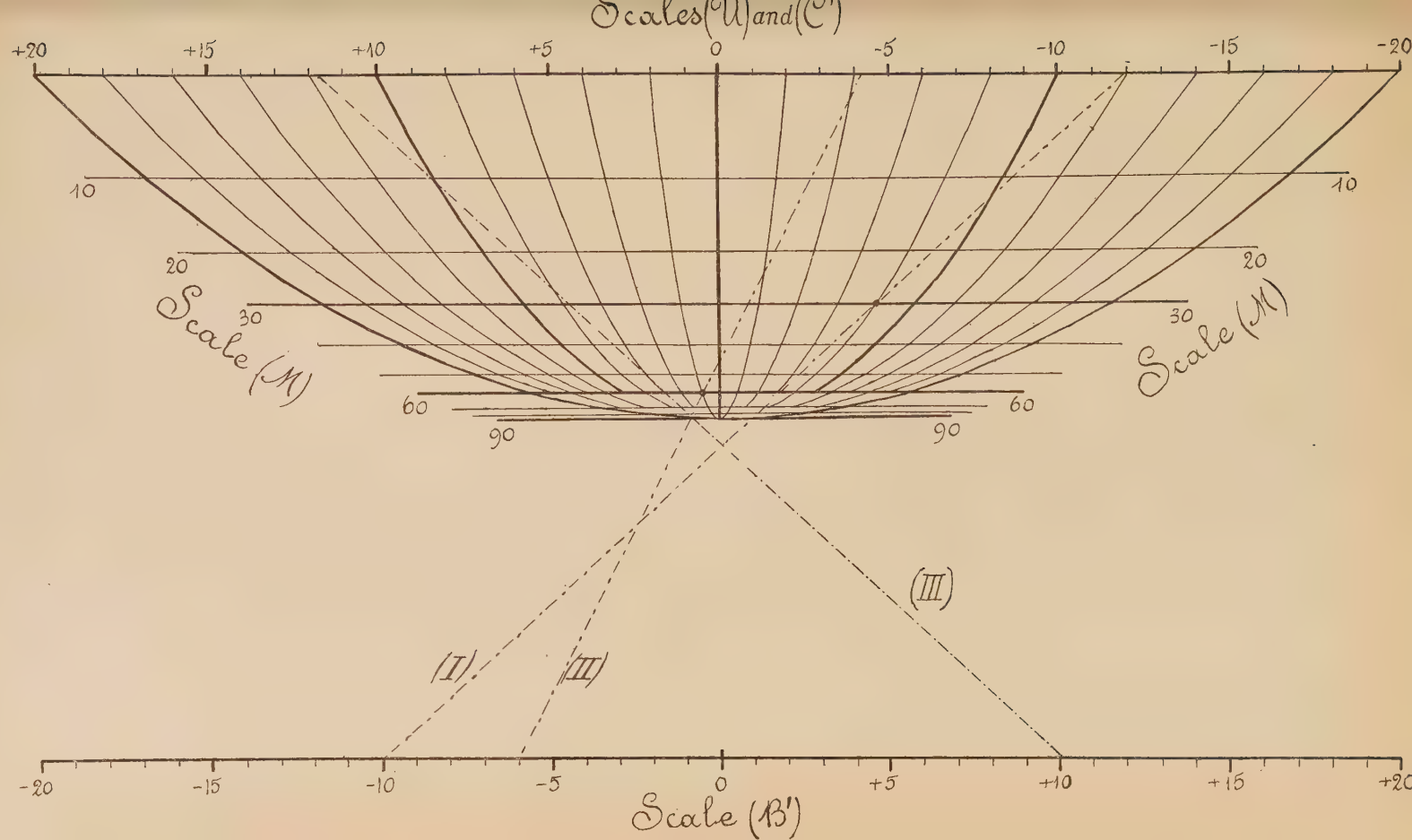
corresponding to $M' = 30°$, by means of the line (I) drawn upon the figure,[14] we find $-11.9°$ for the semicircular deviation and by means of the line (II) we find $-4.2°$ for the quadrantal deviation; thus

$$\delta_{30°} = +1° - 11.9° - 4.2° = -15.1°.$$

Since equations (24) and (25) give respectively the *polar force* R and the complement of the *starboard angle* α' reduced to the first quadrant, by means of the line (III) and with the same data B' and C' we find $R = 12.8°$ and $\alpha' = 51°$; as B' and C' are both negative, $\alpha = (90° - 51°) + 180° = 219°$. In the same way we would have the corresponding elements of the quadrantal force.

[13] We have added a prime to the common notations of the approximate coefficients in order to save confusion with other notations used before.

[14] These lines are really drawn for the sake of clearness in demonstrating, but evidently they are not necessary, and to determine the point C a drawn thread of cotton, silk or metal is sufficient.


Scales (A) and (C)
+20
+15
+10
+5
0
-5
-10
-15
-20
10
20
30
60
90
Scale (M)
Scale (M)
(I)
(II)
(III)
-20
-15
-10
-5
0
+5
+10
+15
+20
Scale (B')

By changing the graduation of the scales we could have the components of the total directive force, the semicircular force and the quadrantal force in function of the exact coefficients.

With a nomogram three or four times as large as the figure we think we could obtain sufficient approximation, certainly not less than that obtained by Napier's diagram or with Colongue's dygogram with the same dimensions as our nomogram. Truly, we do not think that our nomogram can be replaced by these two diagrams, because its use (which can be explained in the blank spaces) is just as convenient and prompt; and while this nomogram is useful and ready for any value of the coefficients, the other two diagrams have to be completely reconstructed if only one of these coefficients varies; it is our opinion that once constructed our nomogram can be useful to those who deal with the compensation of compasses.

Livorno, Italy, May, 1909.[15]

[15] This article was especially written by Dr. Pesci for the U. S. Naval Institute Proceedings and especially translated by Lieutenant Radler de Aquino. See also his *Nomograms for Deducing Altitude and Azimuth,* etc., in these Proceedings for June, 1908.—*R. de A.*

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

MORE LIGHT ON SHIPBOARD.[1]

By Assist. Naval Constructor R. D. Gatewood, U. S. Navy.

1. The tremendous advance accomplished in recent years on shore in the science of illumination has not been duplicated on board ship, and compared with that of a well designed office system, lighting in staterooms, crew's quarters and living spaces in general on naval vessels is well behind the latest practice on land. In this particular phase of increased efficiency the times have moved and we can hardly be said to have moved with them.

2. It is difficult to determine upon a definite lighting standard of so many foot-candles[2] for each type of quarters on account of the large number of difficulties not encountered in shore installations, such as low deck height, deep beams, uniform cases, mess table stowage, ventilation, firemain and other large piping, causing the lights to be masked. The chief faults at present are (1) insufficient direct illumination; (2) insufficient general illumination; (3) lamps presenting brilliant points in line of vision. As a result of this the efficiency of work of all kinds done below deck is considerably impaired and eye strain is greatly increased.

[1] This paper is based entirely upon the belief that the tungsten filament will be so greatly improved as to overcome the defect of fragility; but even if this is not done, much could be accomplished in the interests of improved efficiency of lighting by a photometric study of the principal compartments of a ship, by the installation of metal or a metalized filament lamp, by the use of frosted bulbs, and by the introduction of prismatic glass reflectors.

[2] A foot-candle is the unit for measuring the amount of light. The amount of light at a given point varies inversely as the square of the distance of the point from the source of light. Considering the source of light as emitting 16 candle-power, the amount of light one foot from the source will be 16 foot-candles; the amount of light two feet from the source will be 4 foot-candles; and the amount of light four feet from the source will be one foot-candle.

3. The lights now in use in the service are practically the original carbon filament lamps. Lately, however, there has been developed the "Gem" or "G. E." metalized filament, which is a greatly improved carbon filament type, giving a positive gain of 20 per cent in efficiency over the ordinary carbon lamp. This gain is due almost entirely to the higher temperature at which it is possible to burn the filament. The efficiency of a lamp is stated in watts per candle-power, and is obtained by dividing the total watts by the candle-power emitted. The ordinary carbon lamp burns about 3.1 watts per candle-power. The "Gem" lamp burns only 2.55 watts per candle-power. The life of this lamp is also considerably greater, and the light better, than that of the ordinary carbon filament.

4. But little attempt has been made to use this type of lamp in the service so far as the knowledge of the writer extends. The replacing of all lamps now in use throughout naval vessels after the life of the lamp has expired with even this G. E. metalized lamp would be a most welcome change to all concerned, and would add considerably to efficiency and comfort below deck.

5. If this can be said of the metalized filament, what can be said of the truly remarkable newly developed tungsten filament. It is this latest development of the latter filament that has made it at all possible to consider its use on shipboard. This tungsten is a strange metal, and an enumeration of a few of its characteristics may be of interest at this point.

6. It has a melting point of about 3000° C., which is higher than that of almost any other known metal, and thus is particularly well adapted for light producing. When at a high temperature it has in a remarkable degree the ability to remain stable, and at the same time possesses that very desirable attribute of any lighting filament known as "selective radiation," by which is meant that a very large proportion of its radiations are in the visible spectrum. These last two physical characteristics account in a large measure for the increased efficiency it is possible to obtain by means of this element.

7. Although the queen of metals in the question of melting points, strangely enough it oxidizes at a comparatively low temperature, and a filament becomes plastic and can be worked with more or less ease at a temperature as low as 275° C. When cold, however, the filament as formerly manufactured was exceedingly

brittle and this until very recently has been the prime drawback to the development of the lamp, of which there will be more to be said later.

8. The original manufacture of the tungsten filament consisted of a process called "sintering," which was nothing more nor less than a welding of a large number of small pieces of the metal at a very high temperature. While this general process was being experimented upon to obtain a stronger filament by some of the most expert engineers and chemists, the work of improving the mechanical connections of the filaments in the lamps themselves was making good headway. In the place of the first lamps, in which each separate thread of the metal was soldered in place separately and fused to a rigid support, a continuous thread was wound throughout and was not rigidly fastened at any point except at the leading-in wires. It is to be noted, however, that such a practice was not of course possible until the above "sintering" process had been so much improved as to admit of the manufacture of the filament in longer lengths, and even with this improvement, the greatest care is required at the point where the filament joins the leading-in wire. This type of lamp presented a marked improvement, but for many practical purposes the lamp was still entirely too fragile, and, for use on shipboard, impossible. One discharge from a 12-inch gun would have put most of the lamps in the ship out of commission. This filament has been very aptly compared to glass, in that it has considerable tensile strength and can be bent; the smaller the diameter the more bending it will stand. When warm it becomes quite soft, but when cold is fragile and heavy, vibrations such as those due to gun-fire shattering it. This is rendered all the more difficult on account of the extremely small cross section of the tungsten filament (many times smaller than that of carbon, and too infinitesimally small and irregular at the same time to be accurately measured by any known means except electrically, the filament of a 25 watt lamp being only 1/1000 of an inch in diameter).

9. These improvements, first in the filament, then in the method of internally supporting it, and, finally, in supporting the entire fixture, have recently been more or less overshadowed by the discovery, after years of patient effort at the research laboratory of the General Electric Company, of a method of producing pure tungsten in the form of a continuous filament, so ductile as to

be drawn into the finest wire, and possessing a truly extraordinary tensile strength. There can be no doubt that this discovery, coupled with the improvements above mentioned, will be the means of overcoming the defect of fragility, thus rendering the use of the tungsten light possible in all those places where this defect had precluded its adoption, one of the most important of which is on shipboard.[3]

ADVANTAGES OF INTRODUCING TUNGSTEN.

1. *More Light.*

10. The primary advantage to be obtained is *more light*. Any gain in this connection presupposes an actual *need* of additional light. That there is such a need will not be disputed for an instant by seagoing officers.

This is not the time nor the place to make any extensive criticism of the present system employed in lighting ships, but the efficiency of such a system can well be questioned from a scientific and practical standpoint when it is considered that the amount of light in the various spaces of a ship is calculated approximately as follows:[4]

11. The actual determination of the *amount* of light to be supplied in certain places seems to have received but scant attention.

[3] A few tantalum lamps were tried some time ago on different vessels and were unfavorably reported on by the commanding officers on account of their fragile nature. The Bureau of Equipment is about to make a trial installation of tungsten lamps embodying many of the latest improvements. It is hoped that a more favorable report will be received on these later lamps and that the defects as they develop may be entirely overcome by the expert representatives of the leading companies. Surely the probability of receiving a contract to "tungsten" the navy should present to these companies a goal worthy of the efforts of their ablest engineers.

[4] NOTE.—Taken from "Electrical Installations of the U. S. Navy" by Commander B. T. Walling, U. S. N., and Julius Martin, E. C., Master Electrician, Equipment Department, Navy Yard, New York.

"Room, Handling, Turret.—The lighting to be based on 500 cubic feet of space to each 16 candle-power fixed lamp. . . . ."

"Shop, General Work.—The lighting to be on a liberal basis approaching 500 cubic feet of space to each 16 candle-power fixed lamp. . . . ."

"Admiral's and Captain's Dining-room, Wardroom, Messroom.—Ceiling fixtures No. 1 for overhead lighting on the basis of 400 cubic feet to each 16 candle-power fixed light. . . . ."

To do this would require a little time and a few photometric tests in staterooms, wardrooms, firerooms, living quarters, etc., on ships actually in commission, but it could be done and, in the opinion of the writer, should be done, and a standard of lighting in certain locations accurately obtained as so many foot-candles, and the lights distributed on this more rational basis. To try to do this in an exact way in an engine-room would be impossible on account of the numerous obstructions, shadows, etc., and also on account of the large number of special lights for illuminating such special features as gage glasses, annunciators, manifolds, indicators, etc., but it is believed to be entirely practicable in many other places, and at least it would be possible to determine definitely just *what* is required, and thus make it easier to meet the requirements than at present.

12. This element of the problem solved, the actual distribution of the lamps to accomplish the above result, namely, the providing of a given number of foot-candles, say over a stateroom desk, would be fraught with many difficulties, and in many instances would have to be solved differently on each ship; but if the problem were attacked in this way, it is believed that a more efficient lighting system would be evolved, at the expense of less lights, wiring, conduit and fixtures.

13. Assuming an old installation on a ship, say of the *California* class, the installation of tungsten lamps in the place of the present carbon lamps, provided the former were fitted with suitable globes, etc., would easily effect an increased lighting efficiency of 40 per cent at an equal dynamo output, or, to put it another way, the same amount of light could be obtained as at present with a much less dynamo output, and hence saving of coal and water, and with a reduction in the number of lights and fixtures of at least 20 per cent. In a new installation, say of the 28,000-ton *Oklahoma,* it is believed, if the tungsten filament is sufficiently well developed by the time the lighting of that vessel is to be installed, that a lighting system can be installed that will give at least 30 per cent more light than that now on large battleships, that will weigh less in proportion by from 2 to 3 tons of dynamos, wiring, fixtures, conduit, hangers, spares, etc., and that will cost actually less in proportion.

14. It must be understood that the remodeling of an old system to burn tungsten lamps in sockets now provided for carbon,

will necessitate the renewal of many fixtures, though not all, for the reason that we are dealing with a light of much more intrinsic brilliancy, a higher powered explosive, so to speak, requiring more care in its use. To replace all carbon lamps now in use with clear tungstens would actually give us a much poorer scheme than that now installed. A bare electric lamp has but little place in the illumination of any occupied space, such as crew's quarters, staterooms, etc., and the new lamps would require to be bowl frosted, and in many places, particularly staterooms, fitted with prismatic reflectors. The actual gain due to more light is impossible to measure, but in such a matter definite figures are perhaps not as potent as a consideration of such facts as the following: More light means better vision, less fatigue and more cheerful environment. Light stimulates; darkness depresses. Men work more rapidly and accurately in a bright light and away from depressing surroundings. Light reduces liability of errors and saves time.

2. *Better Light.*

15. Besides this increased light and the saving that can be effected in weight, we get a light of better quality; that is, one more nearly like sunlight and free from the yellow light of the carbon filament.

3. *Efficiency Retained Until Lamp Burns Out.*

16. Tungsten lamps retain their efficiency much longer than carbon lamps, and while the average carbon lamp will burn down to as low as 50 per cent of its rated candle-power before its life is gone, tungsten, though having a longer life, burns out before it has fallen more than 10 per cent in candle-power. The enormous gain due to this property of the tungsten will not be appreciated until it is stated that a test of all carbon lamps in a large cruiser showed that over 60 per cent of the lamps were burning with less than 80 per cent of their rated power, due to the vaporizing of the filament causing a deposit of carbon to be formed upon the walls of the lamp, blackening them and reducing the luminous efficiency.

4. *Renders Possible the Use of Frosted Globes.*

17. Since tungsten leaves no deposit on the globe we can employ frosted globes throughout, thus very greatly overcoming

that defect so frequent in lighting systems due to the brilliant incandescent filament directly in the line of vision. This defect is particularly prominent on shipboard (1) because of the low deck height and the necessity for the large number of bulkhead lights and (2) because carbon lamps with frosted globes fall 20 per cent in candle-power in one-half of the time required for the plain bulb (the total life, however, remaining the same), for which reason their use is now limited to absolute necessities.

5. *Less Attention.*

18. This feature of the tungsten also brings up another advantage which, though not as marked on board ship as on shore, is nevertheless appreciable, and this is that with a lamp that retains its full efficiency until burnt out, there is much less need of renewals and less attendance is required.

6. *Wider Range of Voltage Regulation Possible.*

19. The tungsten lights admit of greater errors in voltage regulation without materially affecting the life of the lamps. For example, an increased voltage of 4.5 volts on a 125-volt circuit will halve the life of a carbon lamp, while to halve the life of a tungsten on a similar circuit would take an increase of about 6.25 volts.

7. *Saving of Power.*

20. The efficiency of the tungsten is so high, about 1.25 watts per candle-power as against 3.5 for the carbon, that a considerable saving in power can be effected and still produce a great deal more light.

Disadvantages.

21. (1) The prime disadvantage will be the increased first cost. Not only will the lights themselves cost more, but it will be necessary to change the type of fixtures and globes now in use to accommodate the added brilliancy of the new light. In a new installation this can be entirely offset by the smaller first cost of a dynamo of less power than would be required with carbon, less conduit and hangers, fewer lights and fixtures, although providing much more light. But in thus increasing the efficiency of an existing system of carbon lights, there is no doubt but that the

cost would be considerable. Much of this will undoubtedly be overcome by a reduction in the cost of the lamp as progress is made in improving the filament and the entire lamp.

22. (2) It will probably be necessary to carry the two types of lamps on all ships for some time to come, as it is doubtful if the tungsten filament will be developed to such a point as to admit of its use in a horizontal position for some years yet.

PRISMATIC REFLECTORS.

23. The adoption of tungsten and bowl frosted globes should be accomplished by the introduction of suitable reflectors. The increased efficiency that can be effected by proper use of this very valuable accessory is not thoroughly appreciated even by many who ought to be entirely familiar with the subject. The primary purpose of reflectors is to change the distribution of light by means of reflection in order to (1) increase the amount of illumination; (2) afford a protection to the eyes, and (3) improve the appearance of the installation.

EFFICIENCY.

24. The bare carbon lamp, when used in connection with low deck height and white painted ceiling and bulkheads, provides a very considerable volume of light. The difficulty is that it is not controlled, the lamp throwing light in all directions, and no means is provided for concentrating it upon the plane it is desired to illuminate. The use of reflectors is not so simple as it appears and, like nearly all apparently easy everyday problems, should be approached in the light of a little applied science and engineering experience. The more or less recently devloped Holoplane reflectors or prismatic glass seem to furnish the most satisfactory candle-power distributions. As now manufactured, they consist of three general types; the extensive, intensive, and focusing, variations from these being made to suit almost every conceivable local arrangement. As yet it is not believed that any suitable type of Holoplane reflector has been developed for a bulkhead light, but it is believed that this, together with the much larger and more general problem involved in the extensive use of reflectors would be cheerfully solved, free of all charge to the government, by the illuminating engineers of the companies who would be only too glad to explore a field that offers such a large possibility for increased business and added efficiency for the naval service.

Eye Protection.

25. The shade reflectors used to accomplish this end are usually opaque themselves, and while directing the light upon a given plane, they leave the bare lamp exposed, and a zone of darkness in the immediate vicinity of the lamp. The eye, looking from the light into the comparative darkness around it and back again to the light, suffers repeated shocks and the result is eye-strain and a probable permanent impairment of vision. A certain amount of general lighting should always accompany direct illumination, and the use of prismatic glass reflectors affords this general illumination.

Appearance.

26. But little will be said under this heading, as the subject is one which must be considered almost entirely from a utilitarian point of view. It is believed, however, that even this sentimental phase of the matter may appeal to those who like to believe that our battleships are up-to-date in every particular, and who will enjoy the added cleanness and smartness presented by an installation of bowl frosted tungsten lamps fitted with suitable prismatic glass reflectors.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

INCORRECT ADJUSTMENT OF RANGE FINDERS.

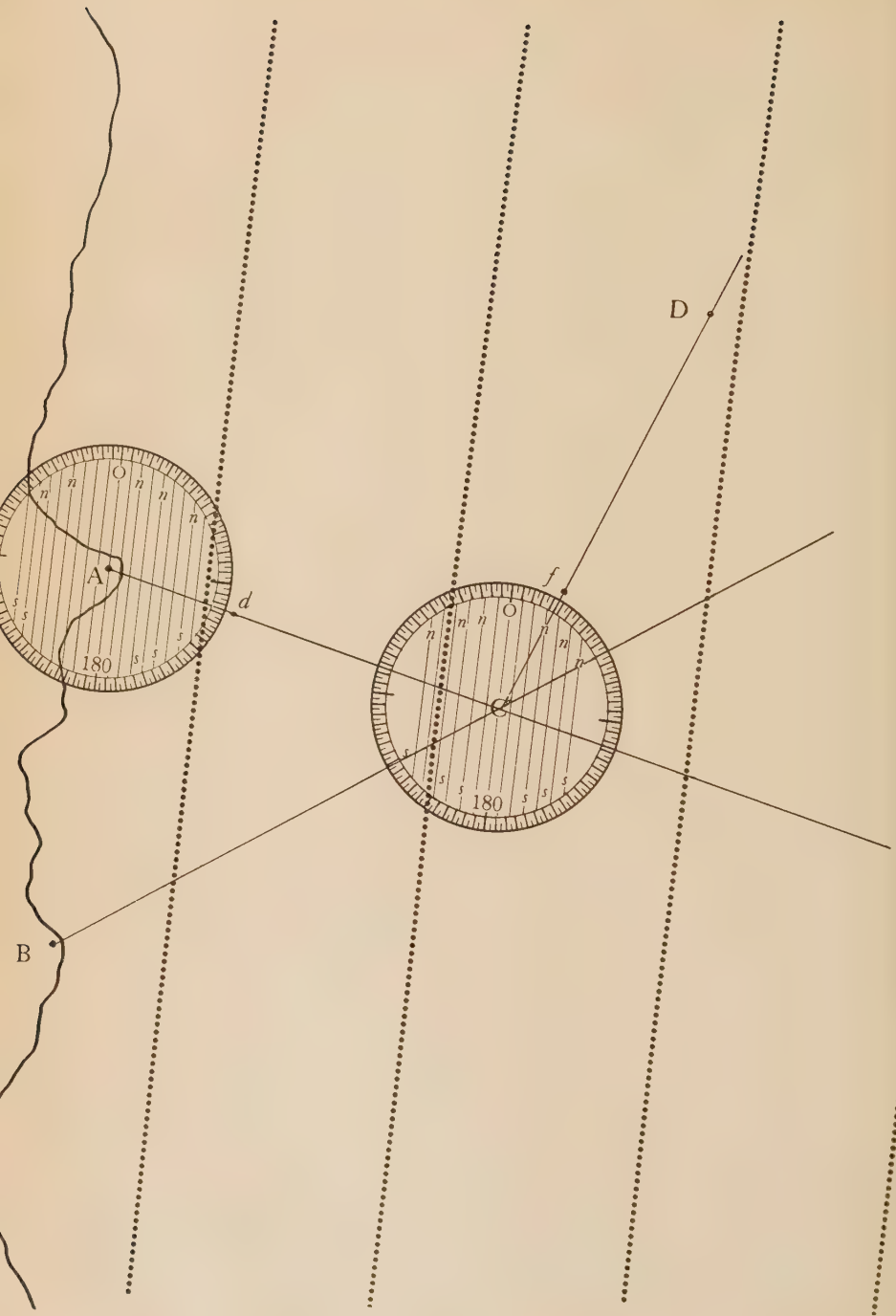
By Captain Bradley A. Fiske, U. S. Navy.

Judging from the published reports of target practice, much of the disagreement in opinion regarding the accuracy of range finders is due to the fact that some range finders have been adjusted on a heavenly body *when it was not in the horizon.*

The reason why it is incorrect to adjust on a star above the horizontal plane is that the rotation of the instrument upwards bows the instrument in a plane not perpendicular to the plane joining the prisms. If for instance, a range finder were correctly adjusted, and were then rotated to sight at a star in the zenith, the weight of the instrument between its supports would bow the instrument in a plane joining the prisms, thereby converging the prisms; and the same result would be produced, though in a less degree, if the instrument were sighted at a star which was at any altitude between the zenith and the horizon. Conversely, if a range finder is adjusted in a plane not horizontal, the angle between the two-end prisms will change as soon as the instrument is rotated to take measurements in the horizontal plane, and *all* its readings will be incorrect.

It may seem absurd to suppose that the mere changing of the plane of observation of a range-finder would make errors large enough to merit consideration; but the seeming absurdity disappears, as soon as we realize that a departure of one second of arc from the correct angle between the end prisms of a 54-inch range-finder causes an error at 10,000 yards of 650 yards.

Of course, it is very seldom that a heavenly body in the horizon can be seen clearly enough to use it for adjusting. To remedy this trouble, the "range finder corrector" was devised as described in the Naval Institute for September, 1908.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A SUGGESTION ABOUT CHARTS.

By Captain Bradley A. Fiske, U. S. N.

The suggestion is to place on charts a number of dotted lines about 4 inches apart, parallel to the magnetic meridian, and to use circular, transparent protractors about 5 inches diameter, marked with lines $\frac{N}{S}$, parallel to 0°, for getting lines of direction: thus avoiding parallel rulers.

To lay down a line—say *AC*—whose direction has been taken from the compass, put the center of the protractor over *A*, with the lines $\frac{N}{S}$ parallel to the dotted lines (which can be done very quickly and accurately), make a dot *d* on the chart opposite the proper graduation and draw *AC*.

To find the direction from *C* to *D*, draw *CD*, place the protractor over *C* and note the graduation at *f*.

The same suggestion applies to mooring boards and plotting boards.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

EARLY VOYAGES OF AMERICAN NAVAL VESSELS TO THE ORIENT.

By Charles Oscar Paullin.

IX.

The Cruise of Commodore Read: 1838-1840.[1]

The cruise of Commodore George C. Read was the ninth in the list of cruises in the Orient made by our naval vessels in the years 1800-1840. As it is the last whose events will be treated in a strictly chronological order, it may be well to enumerate these several cruises by way of recapitulation:

(1) *Essex,* Captain Edward Preble, 1800.
(2) *Peacock,* Captain Lewis Warrington, 1815.
(3) *Congress,* Captain J. D. Henley, 1819-1821.
(4) *Vincennes,* Master-Commandant W. B. Finch, 1826-1830.
(5) *Potomac,* Commodore John Downes, 1831-1832.
(6) *Peacock* and *Boxer,* Captain David Geisinger, 1832-1834.
(7) *Peacock* and *Enterprise,* Commodore E. P. Kennedy, 1834-1837.
(8) *Vincennes,* Commander J. H. Aulick, 1835-1836.
(9) *Columbia* and *John Adams,* Commodore George C. Read, 1838-1840.

The *Columbia* was the second 44-gun frigate to visit the Orient, the first being the *Potomac.* Both vessels, it so happened, were built at the Washington Navy Yard. The *Columbia* was of seven-

[1] See Letters to Officers of Ships of War, XXV, 204-206; Captains' Letters, November, 1838, 2; December, 1838, 2; January, 1839, 49; February, 1839, 14, 44; April, 1839, 40; May, 1839, 21, 101; June, 1839, 33; July, 1839, 731; August, 1839, 4; Belcher, J. H., Around the World, I, 209-336; II, 5-300; Taylor, F. W., The Flag Ship, I, 164-388; II, 9-254; Murrell, W. M., Cruise of the Frigate *Columbia;* Chinese Repository (Canton), VII, 599-656; VIII, 1-37, 57-83; and House Ex. Doc., No. 119, 26 Cong., 1 Sess.

teen hundred and twenty-six tons burden, carried four hundred and eighty officers and seamen, and cost to build four hundred thousand dollars. Her consort, the *John Adams,* was a second-class sloop of seven hundred tons burden, with a complement of one hundred and ninety officers and seamen.

Commodore Read was of Irish birth. He entered the navy in 1804, and, passing somewhat rapidly through the various grades of the line, became a captain in 1825. In the War of 1812 he served as a junior officer on board the *Constitution* and *United States,* and as the commander of the *Chippewa.* He participated in the famous fights between the *Constitution* and *Guerrière* and the *United States* and *Macedonian.* In the former, under orders from Captain Hull, he took possession of the *Guerrière* on her surrender. After his cruise to the Orient in 1838-1840 he served as commander-in-chief of the Mediterranean and the African squadrons. A few weeks before he died, in 1862, he was promoted to be rear-admiral on the reserved list.

The commander of the *John Adams,* Commander Thomas W. Wyman, entered the navy as midshipman in 1810, and died as captain in 1854. The executive officer of the *Columbia* was Lieutenant George A. Magruder, who later became a warm sympathizer with the secessionist movement, and who, in April, 1861, was dismissed from the navy, having previously served as chief of the bureau of ordnance and hydrography of the navy department. Four lieutenants of the *Columbia,* John W. Turk, Thomas Turner, James S. Palmer, and A. M. Pennock and two midshipmen of the *John Adams,* Donald M. Fairfax and Robert H. Wyman (a son of Commander Wyman), later became rear-admirals. The executive officer of the last-named ship was Lieutenant Andrew H. Foote, one of the most distinguished naval officers of the Civil War, and for a time commander-in-chief of the Mississippi squadron.

Commodore Read's sailing orders, which were dated April 13, 1838, and were signed by Secretary of the Navy Mahlon Dickerson, directed him to visit various African and Asiatic ports for the protection of our commerce. The two vessels sailed together from Hampton Roads on May 6. Separating at Rio Janeiro, they did not join each other until they reached Bombay. The *Columbia* had intended to call at the Cape of Good Hope, but owing to heavy weather near the Cape she passed on into the Indian

Ocean and did not anchor until she reached Muscat, on October 16. Here the Prince of Muscat, the third son of the Sultan, did the honors, as his father was not at the capital. He and the commodore visited each other and exchanged friendly expressions of mutual regard. He sent the commodore liberal supplies of goats, kids and fruits; and the commodore returned the favor, in part at least, by sending the Prince "some lines of poetry" in compliment of the Sultan's generous conduct toward the officers and crew of the *Peacock* and in praise of that ruler's admirable character. The poetry was the handiwork of the Reverend Fitch W. Taylor, chaplain of the squadron. From Muscat the *Columbia* sailed for Bombay.

Meantime the *John Adams* had visited Zanzibar, where Wyman and his officers found the Sultan of Muscat, who received them at his palace. "The usual congratulations were offered," wrote one of the officers, "the Sultan expressing himself highly delighted at seeing so many of his good friends, the Americans. He inquired in polite and handsome terms after the health of the President of the United States, and was shocked to learn the political death of his old friend and correspondent, General Jackson; for he could not comprehend how an individual when once at the head of affairs could ever be anywhere else and remain in the land of the living. Of those officers of the *Peacock* whom he had seen three years before, his inquiries were anxious and friendly. He wished to know if we bore any letters from the President to himself, and, when answered in the negative, seemed quite surprised. After many interrogatories into the present state of the Ottoman Porte, the nature of the existing difficulties on the Persian frontier, and various other subjects—many of which, by-the-by, being queries belonging to that numerous class of questions more easily asked than answered—in all which his highness displayed much intelligence and political acumen, and during which he was most courteous and bland; conversation was interrupted by the entrance of some Abyssinian eunuchs bringing coffee." This was succeeded by sherbet, both articles of poor quality. The Americans now took their leave "much pleased with the dignity of grace and benignity displayed by his highness."[2] From Zanzibar the *John Adams* proceeded to Bombay, where she was joined by her consort.

[2] Belcher, J. H., Around the World, I, 269-270.

The British government in India extended many courtesies to the visiting squadron. Commodore Read wrote to the Secretary of the Navy:

> It affords me great pleasure to be able to say that I received very polite attentions from the public authorities at Bombay. The Governor gave myself and the officers of the two ships a dinner. Lieutenant-General Sir John Keane, the commander-in-chief of the military forces, also was pleased to do the same. The Governor invited me to spend some days with him in the country, and many of the English residents called upon me. Indeed, had I stayed longer than I did, I am assured there would have been no lack of attention or want of hospitality. On the day previous to my leaving Bombay, I received His Excellency the Governor, and Sir John Keane, accompanied by their suites, on board the *Columbia* to dinner. The day passed very agreeably. The guests seemed much to enjoy themselves. Many kind and friendly speeches were made by the Governor and Lieutenant-General referring to the United States, and always concluding with the expression of the hope that the two governments might remain at peace and forever continue to be friends.[3]

Sir John Keane, who became Baron Keane of Ghuznee and of Cappoquin, was one of the principal British officers at the Battle of New Orleans, in which he was twice wounded. After his two superior officers, Generals Pakenham and Gibbs, were killed, the command devolved upon him, to whom fell the melancholy duty of leading the defeated army off the field. At the dinner at Bombay given by Read to the British functionaries, one of our naval officers in answer to an allusion by Sir John to the field of his defeat, remarked to him that "he had regained in India all that he had lost in America," to which compliment Sir John gracefully and wittily replied: "Oh, no! not quite. Tell General Jackson that I have never yet regained my former assurance of British superiority over her brothers in America, which she lost at Orleans; nor can I ever lose this Kentucky memento (striking emphatically a wound in the leg, by which he was still maimed), this parting impression which the old general made on me."[4]

From Bombay the *Columbia* and *John Adams* sailed for Goa, being the first American warships to visit that ancient seat of the Portuguese dominions in the Orient, and thence they proceeded to Colombo, Ceylon. Here another round of hospitalities were extended to the officers of the squadron. One evening they dined with the governor of Ceylon, the Right Honorable James

[3] Captains' Letters, December, 1838, 2.
[4] Belcher, J. H., Around the World, I, 336.

Alexander Stewart-Mackenzie. His wife was Maria Elizabeth Frederica Stewart-Mackenzie, formerly Lady Hood, having first married Sir Samuel Hood, vice-admiral of the white. Her second husband adopted her maiden name, Stewart-Mackenzie. In 1815 she succeeded to the family estates in Scotland and became the chieftainess of the clan Mackenzie. Sir Walter Scott refers to her as having "the spirit of a chieftainess in every drop of her blood," and "as an enthusiastic highlander in all manner of northern tradition." A glimpse of the governor and his lady as they appeared at the dinner given in honor of the Americans is presented by one of the officers of the *Columbia*:

We reached the Governor's house, a spacious mansion, at half-past seven o'clock. Commodore Read and his officers were severally presented to Mrs. Mackenzie, the Governor's lady, who entered the room with her hat on, as her head-dress, which we humbly conceive to have been in great bad taste, while her ladyship was prodigal with her smiles, and with great frankness and goodness of heart, placed her guests at their ease. The Governor's self, in lace and silver epaulets, soon presented himself, that others might be presented to him. He entered the reception room after a number of the guests had arrived, with ease, but less with the air of a polished courtier than the plainer gentleman of education and great good sense, who had seen the world and knew its different phases and its fashions.[5]

While in the midst of "all this cheerfulness and friendly intercourse," the commodore received information that an atrocious murder and robbery had been committed on board the American ship *Eclipse,* on the west coast of Sumatra, and he at once sailed for the scene of the outrage for the purpose of punishing the desperadoes. It appeared that the *Eclipse,* Captain Charles P. Wilkins, had put into Trabangan, twelve miles from Muckie, to purchase pepper; that a party of Malays had been permitted to come on board her; and that they had unexpectedly attacked the crew, killing the captain and an apprentice and wounding the second mate and several seamen. After taking possession of four cases of opium and eighteen casks of Spanish dollars, they left the ship in company with the cook, who had disclosed the hiding place of the plunder. The measures taken by Read to punish this piracy are best described in his own words:

While standing in towards Quallah Battoo, a native of Soo-soo came on board, who appeared to be well acquainted with all the circumstances relating to the case. He informed me that the plan for robbing the

[5] Taylor, F. W., The Flag Ship, I, 397.

Eclipse was devised and matured by some of the principal inhabitants of Mukkee; that it was sanctioned by the Rajahs, and carried into execution by several persons belonging to that place, who were still residing there. He informed me that several persons engaged in the perpetration of the murders and the robbery had afterwards come to Soo-soo, and were still residing there; and that one of the pirates was at Quallah-Battoo.

Having come to anchor three miles from the latter place, I deemed it my duty immediately to make the demand for the pirate and property said to have been conveyed to that place with him. Lieutenant Palmer, accordingly, was sent to the Rajah to make the demand and to say to him that the government of the United States desired to be on friendly terms with the Rajahs of Sumatra, that we had come as friends, but that it would depend upon himself whether we should, or should not, leave him with the same sentiments. The Rajah professed himself willing to comply with my wishes, but stated his apprehension that the man could not be taken for the purpose of delivering him to me; the pirate had many friends, and the people generally feared him, but he would endeavor that night to have him taken while asleep.

Commander T. W. Wyman was sent the following day, and the same excuses were repeated. The hour of sunset of the 24th was named as the limit of the time which would be allowed for the apprehension of the pirate, and the bringing of him on board the *Columbia*. The Rajah was told that unless this were done in the time specified, I should be under the necessity of considering him an enemy, and of proceeding to treat him as such; assuring him that it was impossible for him to convince me that he could not secure and give up a pirate found within the limits of his command.

The hour of sunset passed, and nothing further had been done by the Rajah in compliance with the demand. And I now conceived that all the Rajah had promised had been done for the purpose of gaining time. If I had now left him without inflicting some chastisement, I feared he might hereafter question our power, or have an indifferent opinion of its existence. I therefore caused the ships to be dropped as near to the shore as they could swing with safety; and, having sprung their broadsides to the forts, commenced a fire upon them. The fire of the ships was returned with but three shot. Two of the forts hung out white flags, and, after a few shot well directed at the Rajah's fort, I directed the firing to cease.

As I did not conceive the object for which I contended sufficient to justify the landing of a party of men to destroy the place, after they had had so much time to prepare themselves for defence, I directed the ships to be got under weigh and to proceed to Mukkee. We arrived at the common anchoring ground off that place on the evening of the 30th, and the demand for the offenders who, it was said, were residing there, was immediately made. Excuses similar to those we had before heard were now given for not having confined the persons claimed. I desired to obtain possession of the Rajahs, and invited them on board, but could not prevail on them to come. Having sent another message to the Rajahs on the

succeeding day, and being satisfied that they did not mean to comply with my demands for the persons concerned in the piracy, I directed all preparations to be made for hauling in the ships.

On the morning of the first of January, we commenced towing and warping in; and by half-past 10 a. m. got into an excellent position for sweeping with our fire the peninsula on which the town stood, the two ships now not being more than a cable's length from the edge of the town. No sooner had we commenced this operation, than it was observed that the inhabitants were engaged in carrying off their property from the town. It was impossible to prevent this as early as I could have wished; but a few guns were soon brought to bear, and we saw no more persons employed in this business. A slow fire from a few guns on the main and spar deck was kept up merely for the purpose of preventing any preparations for defence, and for the protection of our men in landing. By half-past 12 p. m. three hundred and twenty seamen and marines were landed and formed on the beach, under the command of Commander T. W. Wyman. The divisions from the *Columbia* were commanded by Lieutenants Magruder, Turk, Turner and Pennock. The marines of the squadron were led by Lieutenant [D. D.] Baker. The two divisions from the *John Adams* were headed by Lieutenants [E. R.] Thompson and [George] Minor.

The firing from the ships ceased, and the expedition moved towards the town with order and regularity. Much anxiety was felt at the moment as to the result. The conduct of the Rajahs the evening before being such, it was believed that a steady and determined resistance would be made, but to my great surprise the party entered the place without opposition. The town was soon after in flames. All the dwellings of the Rajahs and their five forts were destroyed. The guns of the forts, 22 in number, found loaded and primed and matches lighted, were spiked and thrown into the ditch. A magazine of rice and a store-house filled with pepper were destroyed. Some valuable boats of large dimensions, on the stocks, and several of less value were consumed in the flames. In short there was nothing left above ground; and by half-past 2 o'clock p. m. the officers and men had returned to their respective ships, without the occurrence of a single accident.

In the performance and execution of this service, Commander T. W. Wyman exhibited a promptness and energy which could not be surpassed; and, had an enemy appeared to oppose the march of the party, his gallantry would have been conspicuous. To Lieutenant Magruder, executive officer of the *Columbia,* I feel much indebted for the good order and expedition with which the men from the *Columbia* were landed and led by him, and for the previous training they had received, the advantages of which were now apparent. Lieutenants Turk, Turner and Pennock merit my warm acknowledgments, as leaders of their separate divisions; and the conduct of Lieutenant Baker, who led the marines, deserves my unqualified approbation. Much was expected from the marines on this occasion, and much no doubt would have been done, had further proof of their skill and discipline been required. Acting Master [Edmund] Jenkins,

Midshipmen [D. R.] Crawford, [C. St. G.] Noland, [S. C.] Barney, [C. R.] Smith, [Charles] Sinkler, [W. M.] Green, [J. L.] Toomer, [C. M.] Fauntleroy, [James] McCormick, and [Edward] Donaldson, Mr. [J. Henshaw] Belcher, professor of mathematics, Mr. [John] Martin, gunner, and Mr. [Benjamin] Crow, sailmaker, were all embarked in this enterprise, and are spoken of in terms of praise by Commander Wyman, to whose report sent herewith, I must refer you for further particulars of this affair, and for the names of those officers who landed with him from the *John Adams*. He speaks in high terms of them all, and gives me every reason to believe that they merit my approbation and thanks.

The ships arrived at this anchorage [Soo-soo] on the 4th instant [January, 1839] since which time we have been busy taking in water. It was my intention on coming to this place to inflict a moderate castigation upon the inhabitants for having permitted several of the pirates to reside among them, and for not giving them up when the demand was made. But the civil and quiet manner in which they conducted themselves towards our watering party on shore, and their apparently sincere profession of inability, from want of power, to comply with my wishes, restrained me from taking such a step. Indeed, when I landed and saw the miserable places called forts by them, upon which a few four- and six-pounders were mounted, without carriages, and the guns themselves in a state of uselessness and decay, which would render it mere wantonness to attempt putting them in a worse condition, I concluded that it would be better policy to take the credit of exercising clemency towards them, and accordingly took advantage of the circumstance to make all the Rajahs of the place, with the exception of one who was absent and sick, to sign a paper which binds them to offer assistance and protection to American vessels.

Early after my return to his neighborhood, the Rajah of Quallah Battoo sent me a message by a priest of Soo-soo, to say that if I would not molest him again he would pay to the owners of the *Eclipse*, two thousand dollars (being the amount said to have been conveyed by the pirate to Quallah Battoo), at the same time declaring that he had not received a cent of the money taken from that vessel. He affirmed further that he was too poor to pay this sum at once, but that he would give his note, payable in twelve months, to any person duly authorized to receive it. As I found it impossible to obtain possession of either pirates or money, I accepted his proposition and took his note for the amount specified, the payment of which may or may not be doubtful. I gave him in return, a paper stating all the circumstances, under which the agreement was made, which he considers a treaty of peace, and I am told, values it very highly.[6]

The promissory note and treaty of peace of the Rajah of Quallah Battoo is a curious document:

This is the epistle of Po Chat Abdullah, raja of Kwala Batu, to Commander Reej, engaging to pay two thousand dollars —. As to the bad

[6] Captains' Letters, January, 1839, 49.

man, he has not been caught; he has fled. Now this agreement is to pay the said money, within twelve months, to Commander Reej, or to any other ship which shall present this writing, or another equivalent to it, whether a ship of war or a trading ship; only let not another ship make war upon the Country of Kwala Batu. Hereby is peace made with Commander Reej, and hereby does Po Chat Abdullah, raja of Kwala Batu, become his friend as long as he lives. The writing is finished. By the counsel of all the elders of Kwala Batu on the side of Achin. Our words are ended, wishing you peace and tranquility. This writing from Po Chat Abdullah of Kwala Batu is given Commodore Reej on Saturday, the 17th day of the festival month, in the year 1254. Signed as witness by Po Adam, Taku Kadang.[7]

The Rajahs of the neighboring settlements were greatly alarmed by the destruction of Muckie and hastened to make their peace with the commodore, who supplied them with "treaties." From Sumatra the squadron went to Singapore, where a supply of provisions was obtained. As many seamen were suffering from varioloid and the bloody flux, an intended visit to Siam was abandoned, and the squadron sailed for China. During the voyage up the coast the *John Adams* parted company with her consort and called at Manila. The *Columbia* anchored at Macao on April 28, 1839. Her arrival was most opportune, for the Americans at Canton were besieged by the Chinese. Seldom indeed has one of our warships received a more hearty welcome at a foreign port. To make clear the situation at Canton, the events there of the past few months must be recounted.

For many years foreign merchants, chiefly British, though a few American, had been engaged in the highly profitable opium trade between India and China, notwithstanding the importation of that article was interdicted by the Chinese government. Many Chinese officials however, connived at the illicit traffic and shared in its profits. It was greatly increased by its being thrown open to all British merchants on the discontinuance in 1834 of the monopoly long enjoyed by the British East India Company. The opium imported into China in 1838 was valued at seventeen million dollars. It was in that year that the Emperor began to take active measures for the suppression of smuggling. He appointed Lin, one of his ablest and most energetic viceroys, high imperial commissioner, and gave him full power to stop the importation, sale and use of the proscribed drug. Lin arrived at

[7] Captains' Letters, April, 1839, 40, enclosure G.

Canton on March 9, 1839, and at once demanded that all the opium held by foreigners should be immediately surrendered to him to be burned, and that the foreigners should enter into "bond" assenting to the confiscation of all ships on which opium should be found, together with their cargoes, and to the punishment with death of the companies of all such ships. On March 22 the foreign trade with Canton was stopped, and shortly afterwards the foreigners were deprived of their Chinese servants. A guard was placed around the factories, all the streets (with one exception) were walled in, a double tier of armed boats was stationed in the river, and communication with Whampoa was cut off. Some five or ten thousand Chinese collected in the immediate vicinity of the factories.

The timely arrival of Commodore Read not only reassured the frightened prisoners at Canton, among whom were our consul, Mr. P. W. Snow, and several American merchants, but it also allayed the apprehension of the foreigners and native Portuguese at Macao, which place was threatened with capture or destruction. Advised by Snow, Read decided to remain at Macao, ready at any time to protect his countrymen there or at Canton, should violence be offered them. The officers of the fleet much preferred to rescue by force the prisoners at Canton, which, Read declared, "would have been more of an amusement than a trouble to us," to waiting idly in port at Macao. The feelings of the Americans is thus described by Chaplain Fitch W. Taylor:

> It would be a fête gratifying, I doubt not, to all the officers of our ship, from the highest to the lowest, to force the Bogue, and to demand without delay the Americans now held within their premises at Canton. But the apprehension is, that, as their numbers are comparatively so small, and a mob of a numerous populace are ever so ready to do the bidding of the reckless and the abandoned, our approach might be attended with danger from the rabble at Canton. The authorities themselves have said, all that they have to do for the destruction of those now within their power is, to allow the mob to do their own wishes. And there may be truth in all this, as there is a general impression among the lower classes of the Chinese at Canton that the foreign factories are filled with the precious metals, and that the plunder were well worth the sacrifice of the heads of the few "foreign devils" that have the custody of it.[8]

It was fear of a massacre of the imprisoned foreigners that led Captain Charles Elliot, the British superintendent of trade, to

[8] Taylor, F. W., The Flag Ship, II, 110-111.

yield to the demands of Commissioner Lin and deliver up to him the obnoxious drug—in all, twenty-two thousand two hundred and ninety-one chests, worth about twelve million dollars. This act of Elliot postponed for a few months the conflict between Great Britain and China. On the delivery of the opium, the guard around the factories was removed, the foreigners were liberated, and trade with Canton was reopened. The British merchants, however, under Elliot's direction, left the city and did not resume their trade. The American merchants, on the other hand, remained at Canton, obtained a verbal modification of the "bond," and by July were actively engaged in commerce.

Commodore Read now felt free to depart on his homeward voyage, and resisting the importunities of Consul Snow and the American merchants to prolong his stay, he prepared his squadron to return to the United States. He was much embarrassed by the awkward situation in which he was placed by the refusal of the Chinese to recognize the authority of foreign naval officers. On one occasion when some Chinese fired most wantonly upon some Manila-men sailing under the American flag and seriously injured them, he urged Consul Snow to demand that the perpetrators of the outrage be delivered up for trial, but the consul refused to act, on the ground that it would be impolitic. Glad to be rid of his embarrassments, Read, on August 6, sailed for the Sandwich Islands. The first night out he encountered a violent typhoon which blew the sails of the *Columbia* to ribbons and drove her rapidly toward the shore to the great alarm of all on board. Happily the wind shifted in season and a disaster was averted. From Honolulu Read sailed for Valparaiso by way of the Society Islands. His voyage came to an end with the arrival in Boston of both ships in June, 1840.

THE OPENING OF CHINA: 1842-1850.[9]

For more than half a century after the notable voyage of the *Empress of China,* no American vessels, unless perchance an opium smuggler or a whaler, were to be seen along the Chinese coast between Canton and Korea—some two thousand miles in

[9] This chapter is based chiefly on the East India Squadron Letters, U. S. Navy Department Archives, 1841-1851; House Ex. Doc., No. 119, 26 Cong., 1 Sess.; Sen. Ex. Doc., Nos. 58, 67, 28 Cong., 2 Sess.; Sen. Ex. Doc., No. 139, 29 Cong., 1 Sess.; and the Chinese Repository, XI-XX.

extent. None of our warships had ventured to pass the Bogue and visit Whampoa and Canton. Several of them—to be exact, nine—had entered the bay of Canton and anchored at Lintin or Macao. But they were regarded as intruders, and received no official recognition from the Chinese government. The time had now arrived when the status of foreign ships of war in China was to be altered, and a serious breach was to be made in the commercial wall which that country had erected on its maritime frontier for the exclusion of foreigners and the isolation of its own citizens.

The events of the spring of 1839 culminating in the destruction of the opium at Canton by Commissioner Lin have already been described. This act of the commissioner was regarded by Great Britain as a just cause for war, and accordingly she sent a squadron to China early in 1840 to redress her wrongs. On reaching its destination, the Canton River was blockaded and one of the ports north of Canton was attacked. As these hostile operations jeopardized our commercial interests, the government at Washington decided to send a squadron to China for their protection. Two vessels were prepared for that service—the historic frigate *Constellation,* famous for her early victories under Truxtun, and the ship *Boston;* and Commodore Lawrence Kearney, a seasoned officer of the old school, was chosen to command them. During the War of 1812 Kearney was employed in protecting the coast of the Southern states, and after that war he was sent to the West Indies and to the Mediterranean to aid in suppressing piracy. In 1861 he was retired as captain, and in 1867 he was promoted to be commodore, dying about a year later, the second oldest officer of the navy.

Kearney's sailing orders were dated November 2, 1840, and were drafted by Secretary of the Navy James K. Paulding. He was directed to protect American interests and citizens on the coast of China, especially during the war between that country and Great Britain. He was to observe the laws of neutrality, and to pay due respect to the peculiar customs of the Chinese. His attention was called to the fact that the foreign and domestic policy of China differed from that of other nations, and he was instructed to avail himself of every opportunity to impress upon the Chinese people and their officials that the one great object of his cruise was "to prevent and punish the smuggling of opium

into China either by Americans or by other nations under cover of the American flag." [10]

When Kearney arrived at Macao, on March 22, 1842, almost two years after the beginning of the Opium War, the British fleet was operating chiefly at Shanghai and on the Yangste-kiang, more than a thousand miles north of Canton. The British had captured Amoy, Ning-po, Tinghai and Chinhai; and had obtained possession of Hong Kong, at the mouth of Canton Bay, where they had established a naval rendezvous. They had taken the forts at the Bogue, pushed up the Canton River, and forced Canton to purchase an immunity from attack by the payment of six million dollars. Kearney arrived too late to see much of the war. The blockade at Canton had been raised, the foreign commerce resumed, and the smuggling of opium again permitted.

A few Americans had long found the trade in this proscribed article highly profitable. Indeed the foreign merchants at Canton did not generally consider this traffic disreputable, and many of them at one time or another were connected with it. When Commodore Downes visited Lintin in the *Potomac* in 1832, one of the officers of that frigate reported that a very fine American ship called the *Lintin* was stationed there "to receive and dispose of opium, of which article most of the contraband trade consists." [11] Our consuls, being generally merchants with commercial interests of their own to subserve, were prone to overlook irregularities committed by their countrymen. Kearney was the first American official to make a vigorous attempt to suppress the traffic. A few days after his arrival he issued the following order addressed to the United States consular officer at Canton:

> The *Hong Kong* Gazette of the 24th instant [March, 1842] contains a shipping report, in which is the name of an American vessel engaged in carrying opium; therefore I beg you will cause to be made known with equal publicity, and also to the Chinese authorities by the translation of the same, that the government of the United States does not sanction the smuggling of opium on this coast, under the American flag, in violation of the laws of China. Difficulties arising therefrom in respect to the seizure of any vessel by the Chinese, the claimants certainly will not, under my instructions, find support or any interposition on my part, after the publication of this notice.[12]

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[10] Letters to Officers of Ships of War, XXX, 44-47.

[11] Reynolds, J. N., Voyage of the United States Frigate *Potomac*, 338; Gützlaff, K. F. A., A Sketch of Chinese History, II, Appendix, Table 4; Brinkley, F., China, X, 261-262.

[12] Sen. Doc., No. 139, 29 Cong., 1 Sess., p. 7.

This edict of Kearney appeared to the British merchants, who remembered the part played by the Americans in the smuggling trade, especially during the opium difficulties of 1839, as a mere affectation of high professions, and as an attempt to curry favor with the Chinese. The fact that the British were fighting for the interests of our commerce as well as their own, made it all the more difficult for them to take a generous view of the edict. Before he left China, Kearney proved to his critics that his government was acting in good faith. In May, 1843, he seized the American schooner *Ariel,* a notorious opium smuggler, and tried to capture the *Mazeppa* and several other illicit trafficers. Writing to the Secretary of the Navy at this time, he said:

> The American flag is now the only cover for this illicit trade. Sir Henry Pottinger [the British plenipotentiary in China] having issued a proclamation against it; and the English craft having been turned away from the river, has placed the Americans in a peculiarly advantageous position as freighters under the flag of the United States. The British officers have informed me here that their subjects defy them by pointing to the American flag over that contraband article.[13]

Soon after his arrival at Macao in March, 1842, Kearney received several letters from American citizens demanding redress for certain outrages committed on them by the Chinese during the operations of the British near Canton in May and November, 1841. It appeared that one of our merchants, Mr. J. Coolidge, had been seized at his factory and imprisoned at Canton, and that another merchant, Mr. Morse, fearing like treatment, had made his escape to Whampoa, with rather disastrous consequences. He left the factories with two boats loaded with his property. The boat on which he embarked reached Whampoa without being molested. The second boat was attacked by Chinese soldiers, and one man, named Sherry, was killed, and the rest of the crew wounded. The survivors were captured and imprisoned in Canton. Later another boat's crew was seized and put in prison. After a brief confinement, however, all the Americans were released.

On receiving information of these outrages, Kearney decided to go to Whampoa and demand redress. On April 11, he left Macao, sailed past the Bogue, and two days later anchored at Whampoa Reach. Never before had an American ship of war, and very rarely had the national vessels of other nations, thus

[13] Sen. Doc., No. 139, 29 Cong., 1 Sess., p. 38.

violated the time-honored sanctity of the inner waters of China. Strange to say Kearney's presence in the river gave no offense to the officials at Canton. On the other hand, they permitted him to disregard the roundabout method of communication hitherto strictly insisted upon, and to send his messages directly to Viceroy Ke, minor guardian of the heir apparent, president of the board of war, member of the censorate, and governor of the provinces Kwangtung and Kwangse.

On April 27 Kearney sent Lieutenant J. G. Reynolds, of the marine corps, to Canton with a letter for Ke, dealing with the outrages committed by the Chinese in 1841. Reynolds delivered this letter to the representative of the viceroy, the Kwangchauhie, the chief military officer of the department, ranking as colonel. Two days later a Chinese officer of the rank of captain delivered to Kearney on board the *Constellation* the reply of his master. The viceroy was in a remarkably conciliatory mood. He submitted the grievance of the Americans to Kearney for his decision and ordered the Hong merchants to pay the damages fixed by that officer, declaring that the firing upon and seizure of the American boats was the result of a misapprehension. While these differences were being thus amicably adjusted, a boat of the *Constellation* engaged in making soundings was fired upon by one of the Chinese forts. On learning of this additional ground for complaint, Ke explained the action of the fort satisfactorily to Kearney and degraded the officer responsible for it.

In placating the Americans, the viceroy did not hesitate to employ flattery and to overlook unpleasant truths. He referred to Kearney as an officer who "manages affairs with clear understanding, profound wisdom and great justice"; and he said that American vessels "hitherto engaged in the commerce of Canton have always been confined to the legitimate and honorable trade, and never concerned with the carrying of opium." He gave Kearney a present of bullocks and sheep, receiving in return an atlas and several other articles of Occidental manufacture. When Kearney visited Canton and was on the point of returning to his ship, the viceroy sent one of his officers to pay a parting call and present his compliments. Never before had an American official received such polite attention from the Chinese government. This unusual conduct doubtless resulted from the determination of the government to keep on good terms with all the neutral nations of

the Occident. Some weight, too, must be given to the wholesome fear of Western powers aroused by the operations of the British fleet.

While the *Constellation* and *Boston* lay at Whampoa, several high officials of the Chinese Navy visited them, and were cordially welcomed by their officers. An account of this visit was written by the Reverend E. C. Bridgman, Kearney's interpreter, and one of the first American missionaries to China.

About noon May 9, the day fixed upon for the admiral's visit, two messengers arrived to announce his approach. But it was past 2 o'clock before his barge was in sight. As he neared the ships, they were in readiness to do the honors due to his rank and station; and the manning the yards and firing of the salute, in most admirable style, were to him a sight equally novel and animating. He was received by the commodore on the quarter-deck, and conducted to the cabin. The admiral, a native of Fukien, was appointed to this station shortly after the battle of the Bogue, where his predecessor fell in the storming of one of the forts. Kwan bore a good reputation among his own countrymen; but in his appearance and whole bearing as a warrior, Wu is decidedly his superior. He is now 44 years of age, tall, well formed, has a high aquiline nose, a keen eye, and moved across the deck with an easy, but firm and manly step. He had hardly been seated in the cabin, before he begged that the men might be put at their ease—he supposing that they were then, as when he came on board, standing upon the yards. At his own request he was shown round the ship, and was afforded an opportunity of seeing the men at their quarters. The marines particularly attracted his attention; and for several minutes, while going through their evolutions, he stood like a statue fixed in perfect amazement. While the men were still at their guns, and without the admiral's knowledge, orders were given to repel boarders on the starboard quarter, where he chanced to be standing. Instantly, almost a hundred or more men, with swords and pikes and fixed bayonets, rushed up from the gun-deck, and took their proper stations. For the moment the admiral found it impossible entirely to conceal his feelings, though the lines of his face were screwed up to the highest pitch he could command. He had been forewarned of treachery by some of the wise men at the provincial city. But his fears were banished, by the men the next moment moving to the other quarter. Still more ludicrous scenes occurred at Canton. The admiral had scarcely left the city for the ship, before the senior Hong merchants were called on to give security for his safe return. And the report of thirteen guns—instead of the Chinese number three—for the salute, was such positive proof of treachery that nothing but the admiral's safe return in person could allay the alarm of the provincial authorities.

It was nearly sunset when the admiral left the ships, evidently much pleased and well satisfied with his reception, and the attentions shown him on board the foreign man-of-war. On Monday the 18th, two other officers,

one the second in command to the admiral, visited the commodore. These men were from northern provinces, and though they had been a year or more at Canton, had never before been on board a foreign vessel. They said they had supposed, from all reports, that the foreign men-of-war were strong, but till then they never believed them so strong as they now found them to be. They seemed astonished when told, that many of the English ships were far superior to the *Constellation*.[14]

The age of the *Constellation* drew from the Chinese officials many exclamations of surprise, and they made "wonderful reports" of the two ships to Yih Shan, a high official at Canton. It happened that at this time Kin Ying Lin, a member of the Imperial cabinet at Peking, laid before the Emperor of China sundry drawings of warships and a recommendation for an increase of the navy. The Emperor sent the drawings to Yih Shan, who later reported, in the form of a lengthy memorial, that only vessels like those of the foreigners were at all proper for fighting, and that in the future China warships ought to be constructed after the models of the *Constellation* and *Boston*. The Emperor ordered that thereafter national ships should be of the kinds recommended. Yih Shan further reported that one vessel had already been built after a foreign model, and that two similar vessels were on the stocks.[15]

On the completion of his mission up the Canton River, Commodore Kearney about the middle of June dropped down to Macao. A month later he went to Hong Kong and exchanged civilities with the British commander there, Rear-Admiral Sir Thomas Cochrane, between whom and the commodore a good understanding existed. It was at Hong Kong that Kearney in September received news that peace had been restored, and that a treaty had been signed on August 29. The Treaty of Nanking, as this epoch-making compact was called, provided for the session of Hong Kong to the British, the payment by the Chinese of twenty-one million dollars, the opening to British merchants of Canton, Amoy, Fu-chau, Ning-po and Shanghai, the residing at these ports of British consuls, the establishment of just and regular tariffs, and the conducting of official correspondence on terms of equality.

Kearney was quick to recognize the great importance of this treaty to the United States, and, on learning its terms, he dis-

[14] Chinese Repository, XI, 333-334.

[15] *The Friend of China and the Hong Kong Gazette*, December 22, 1842.

patched Vice-Consul Delano to Washington with a copy of it, sent duplicates overland by mail, and ordered the *Boston* to proceed to the west coast of Mexico with triplicates. He, however, did not propose to await the action of the home government. Delaying his return voyage, he set about obtaining for our merchants the same commercial privileges granted by the Treaty of Nanking to the British. "The good understanding which happily exists between the local authorities of Canton and the Americans and with myself," he wrote to the Secretary of the Navy, "would seem to recommend this time a propitious moment for the United States to enter upon some understanding in regard to commercial privileges with the Chinese. The liberty therefore of undertaking such a measure will, I hope, find excuse even should I fail of success."

These words were written at Macao on October 7, from which place on the following day he thus addressed Viceroy Ke:

The address of Commodore Kearney, commander-in-chief of a squadron of United States ships, respectfully represents that he learns with deep interest the high Imperial commissioners deputed to arrange commercial affairs with the British are expected in a short time to arrive at Canton, and that a commercial treaty is to be negotiated to operate in favor of "British merchants" exclusively.

The undersigned is desirous that the attention of the Imperial government might be called with respect to the commercial interests of the United States, and he hopes the importance of their trade will receive consideration, and their citizens, in that matter, be placed upon the same footing as the merchants of the nation most favored.

The undersigned does not press this matter at present, but, trusting to the good and friendly understanding which exists, he submits the case, and has the honor to be, your excellency's most obedient servant.[16]

From Macao Kearney went to Canton, where soon after his arrival he received the following favorable reply from the viceroy:

Ke, guardian of the young prince, member of the Board of War, member of the Imperial cabinet, and Governor of the two Kwang Provinces, states, in reply to the subject of the 10th of the 9th month, that I have received your polite communication relating to the English commerce. I, the governor, have ever hitherto treated the merchants of every nation with the same kindness. Moreover, the Americans who have come to Canton have had free commerce, month after month, and year after year. These merchants have been better satisfied with their trade than any

[16] For the correspondence between Commodore Kearney and Viceroy Ke, see East India Squadron Letters, 1841-1844, 33-52; also Sen. Doc., No. 139, 29 Cong., 1 Sess., 21-36.

other nation; and that they have been respectfully observant of the laws, is what the August Emperor has clearly recognized, and I, the governor, also well know. How, then should I not rather, on the cessation of difficulties with the English, wish to show favor to them? Now, I have ordered the Hong merchants, with the said English nation's merchants, to devise beforehand, and to wait the arrival in Canton of the Imperial commissioners, great ministers of state. When I shall have received the newly devised regulations concerning the free trade of the English, then I, the governor, together with the lieutenant-governor and Tartar General, will immediately deliberate upon the proper adjustment of the regulations, and will make a representation to the Emperor that he may hear and direct what shall be done.

Decidedly it shall not be permitted that the American merchants shall come to have merely a dry stick (that is, their interests shall be attended to). I, the governor, will not be otherwise disposed than to look up to the heart of the great Emperor in his compassionate regard towards men from afar, that Chinese and foreigners with faith and justice may be mutually united, and forever enjoy reciprocal tranquility, and that it be granted to each of the resident merchants to obtain profit, and to the people to enjoy life and peace, and universally to participate the blessings of great prosperity, striving to have the same mind.

This is my reply.

As these assurances of the viceroy were quite satisfactory, Kearney made preparations to return home, but finally decided to delay his departure, hoping that an occasion might arise for establishing a good understanding with the officials at Peking. Moreover, the English and Chinese were preparing to open negotiations respecting the new commercial system, and Kearney was of the opinion that the presence of his ship would be beneficial to America, especially should it become necessary "to make demands in favor of equal rights and commercial privileges." Pending the arrival at Canton of the British and Chinese commissioners, he visited Manila, returning to Macao on January 1, 1843. During his absence a Chinese mob attacked the foreign factories at Canton, and destroyed considerable property belonging to the American house of Augustine Heard and Company. To facilitate the settlement of the claims of this company against the Chinese government, Kearney again sailed up the Canton River; and, leaving his ship at Whampoa, went to Canton, and entered into correspondence with Ke, who gave his word that the sum claimed by the Americans should be paid. The most significant part of this correspondence, however, does not refer to these claims, but to the commercial privileges of American merchants.

On this subject Governor Ke wrote as follows in a letter dated March 17:

> On a former occasion, the governor received your honor, the commodore's communication, requesting him, in his behalf, to "solicit the favor of the august Emperor to allow the merchants of his honorable nation to trade upon the same terms as those granted to the merchants of other nations," etc. As in duty bound, the governor having already addressed the Emperor clearly upon the subject, waited the coming of the high commissioners at Canton, where they were in concert to attend to the foreign relations; but the Tartar General, Eleepie, having arrived at this city, but a short time elapsed, when, most unfortunately, on account of disease, he "went out of office" (*i. e.*, deceased)—so that whatever may be just and equal in the trade of each nation, remains unsettled. It is, therefore, necessary to wait the arrival of his successor; and when some plan is adopted, then a personal interview may be held with your honor, the commodore, and, face to face, the relations between the two countries may be arranged, and the same be reported to the Emperor.

In reply Kearney availed himself of the opportunity presented to say that what the Emperor "grants to the traders from other countries, his own sovereign will demand for his merchants." He assured the viceroy that he would not protect Americans seized by the Imperial cruisers in the act of smuggling opium. Respecting the proposal that the Imperial commissioner and himself should fix the commercial relations between their two countries, he said that the viceroy labored under a misapprehension, for he had not been empowered by his government to make a treaty. "If, however," he added, "his Imperial majesty will declare his will on this point, my country will no doubt rejoin to it in the same spirit of amity, and straight return an answer, and send a high officer to China, who, in connection with the Imperial commissioner, will deliberate and settle a permanent treaty of lasting peace and friendship. But to commence this good thing, to open this road of mutual benefit, belongs to his Imperial majesty of China."

Kearney's suggestion respecting the negotiation of a treaty was not approved by Ke, who said that such a compact would be contrary to Chinese custom, and would be "an unnecessary and circuitous act." He further said that the tariff of duties fixed for the English would "pass into force in a uniform manner for every country." He was not informed, however, whether the Occidental countries other than England would be permitted to trade with Fu-chau, Ning-po and Shanghai.

Before leaving China, Kearney went to Amoy, the first port north of Canton to be visited by an American warship, and thence sailed for Honolulu on his homeward voyage. He had performed the tasks committed to him with great tact, skill and firmness, and had served his country most efficiently under trying circumstances. "That little squadron," wrote the Secretary of the Navy of Kearney's command, "had done all that could have been expected of it, and it deserves much credit for its great vigilance and activity and for the prudence and sound discretion with which Commodore Kearney has acquitted himself of the important trusts reposed in him."[17] Three months after Kearney left Amoy the Imperial commissioner issued a proclamation giving to other nations the same commercial privileges granted to Great Britain by the Treaty of Nanking. The monopoly of the Hong merchants now came to an end, many antiquated restrictions on commerce ceased, and a new tariff rate amounting on the average to five per cent went into effect. For the first time China fully opened her ports and her people to intercourse with the Occident and introduced herself to the family of nations.[18]

While China thus gave freely to all the Western powers the privileges Great Britain had forced from her, several of them (Belgium, Holland, United States, Spain, Portugal and France), not knowing of her liberality or unwilling to trust it, hastened to dispatch envoys to treat with her. On learning of the Treaty of Nanking in December, 1842, President Tyler sent a special message to Congress recommending the appointment of a commissioner to China, empowered to negotiate commercial arrangements. Congress did not authorize the appointment until March 3, 1843, and on the same day Edward Everett, then minister to England, was chosen commissioner. On his declining the office, President Tyler selected Caleb Cushing, an eminent lawyer, and a member of Congress from Massachusetts.

A little squadron, under the command of Commodore Foxhall A. Parker, was placed at the service of Cushing, consisting of the frigate *Brandywine,* famous for her having afforded a passage to Lafayette on his return to France in 1825, the second-class sloop *St. Louis,* Commander H. H. Cocke, and the 10-gun brig *Perry,*

[17] Annual Report of the Secretary of the Navy for 1842, p. 532 (in House Ex. Doc., No. 2, 27 Cong., 3 Sess.).

[18] Chinese Repository, XII, 443; Brinkley, F., China, XI, 172.

Commander S. F. Dupont. Commodore Parker had served in 1814 as a lieutenant on board the sloop *Adams* during her successful cruise after British merchantmen. In 1848-1849 he was sent to Germany on a confidential mission relating to the employment of American naval officers in the German Navy, then being organized. He was retired as captain in 1855, and died two years later.

The *Brandywine* and *St. Louis* were the first ships of the squadron to sail, leaving Hampton Roads on May 23, 1843. Parker gave passage to Elisha K. Kane (afterwards a navy surgeon and noted for his North Polar explorations) and four other young men, attachés of Cushing's mission, whose only duty was to add dignity and importance to it. The *Brandywine,* having parted company with her consort, arrived at Bombay on October 24, where she was joined by Fletcher Webster, the son of the Secretary of State, and the Secretary of the Mission, and by Cushing, who, after visiting London and Paris to ascertain the plans and purposes of those governments in their intercourse with China, had taken passage for India by way of Gibraltar. Webster had come out from Boston in the *Antelope,* which ship, together with another Boston vessel, the *Zephyr,* proceeded to take on cargoes of opium for the China trade. Parker was unable to discover any authority vested in him to stop their illicit trafficking.

On February 24, 1844, the *Brandywine* arrived at Macao, at which place Cushing went ashore and established the headquarters of his mission. He at once entered into correspondence with Ching, acting governor of the two Kwang provinces, residing at Canton, informing him of the powers with which he was vested. He expected to go to Peking, deliver a letter of President Tyler to the Emperor, and there negotiate the treaty. To this plan, however, the Chinese authorities firmly, though courteously, objected, and Cushing was finally induced to accept the procedure proposed by the Emperor, namely, that the treaty should be negotiated at or near Canton, and that the Chinese government should be represented by a high commissioner acting under the Imperial seal.

While Cushing was occupied with these preliminaries, Parker visited Manila, Hong Kong and Whampoa. At Hong Kong the United States had lately established a naval depot and a consu-

late; the former Parker moved to Macao, which port he regarded as the more convenient location. On arriving at Whampoa, he wrote to Governor Ching offering to exchange a salute of twenty-one guns, to receive the officers of the Chinese government on board the *Brandywine,* and to pay a visit of courtesy to the governor at his palace. As the war had been concluded and the fears of the Chinese somewhat allayed, Ching was much less inclined than his predecessor Ke to permit an infraction of Chinese customs. He requested Parker to withdraw immediately out of the Bogue and return to Macao. He politely declined to accept the proffered civilities, ascribing as a reason for his declination the dissimilarity between the rules of etiquette of the Central Kingdom and those of foreign nations. He attributed the breaches of Chinese custom made by the "honorable commodore" to the fact that he had never before visited the Central Flowery land, and therefore could not be expected to know its laws. Unable to satisfy the governor, Parker returned to Hong Kong.

On June 16 Kiying, the high commissioner appointed by the Emperor to negotiate with Cushing, accompanied by three distinguished officials, arrived at Casa Branca, a Chinese village adjoining Macao, and on the following day installed himself at Wanghia, just outside the walls of Macao, in a temple dedicated to the Lady of Mercy. After a few days had been spent by the commissioners in exchanging visits of courtesy, Cushing being assisted in these formalities by Parker and several of the officers of the squadron, negotiations were opened on the 21st, when the Americans submitted the draft of a treaty. Twelve days later the negotiations were concluded by the signing and sealing of the Treaty of Wanghia, by Cushing and Kiying, in the presence of Parker and the attachés of the mission. The contents of this rather lengthy document need not here be detailed. It is sufficient to note that it provided for the opening to Americans for purposes of residence and commerce of the five treaty ports, for the admission to these ports of ships of war, and for the protection of shipwrecked sailors and of vessels seeking refuge from storms.

While Parker was at Macao in the service of Cushing, he received a letter from the American consul at Canton asking for protection from a Chinese mob that had surrounded the American factory there. It appeared that the commotion had its origin in

a trespass on the factory grounds committed by the Chinese. When ordered off, they refused to go. Force was used by the Americans, and in a skirmish that ensued, one of the intruders was killed. Parker at once directed a detachment of his men to proceed to Canton, but before it departed he learned that Lieutenant E. G. Tilton, the commander of the *St. Louis,* had anticipated his wishes. On arriving at Whampoa, Tilton embarked sixty seamen and marines of the *St. Louis* on board boats and conveyed them to Canton. He found a Chinese mob in possession of the grounds in front of the American factory. It, however, was easily dispersed, order was soon restored, and he shortly returned to Whampoa with his men.

On August 29, (1844) Cushing sailed for the United States on board the *Perry.* About the same time the *St. Louis* proceeded on a cruise to the North China ports and visited Chusan, still in possession of the British, and Ning-po, where she attracted much attention as the natives had never before seen an American ship of war. She returned home by way of Australia, Van Dieman's Land and New Zealand, being one of the first American warships to visit those islands. Before the *Brandywine* left Macao on December 2, for Honolulu, Parker received a communication from Kiying containing the information that the ministers of the Chinese Privy Council had sanctioned and the Emperor had approved the treaty. On the eve of his departure the Americans at Canton presented him with a superb and massive service of plate in token of their appreciation of his work in behalf of the commercial interests of the United States.

On the approval of the Treaty of Wanghia by the President and Senate, Alexander H. Everett, a distinguished American scholar and diplomat, who had been appointed to succeed Cushing as American commissioner to China, received orders to exchange ratifications with the Chinese government. A new squadron, consisting of the ship of the line *Columbus,* Captain T. W. Wyman, and sloop of war *Vincennes,* Captain Hiram Paulding, both under the command of Commodore James Biddle, a distinguished veteran of the War of 1812, was placed at the service of Everett, who, accompanied with his family, embarked on board the flagship at New York early in June, 1845. Suffering from ill health, Everett on reaching Rio Janeiro decided to abandon his mission and return home, and to transfer to Commodore Biddle his instruc-

tions from the state department and his special power to exchange ratifications with the Chinese government. The commodore arrived at Macao within a few days of the expiration of the period fixed for the execution of this formality. He, therefore, went at once to Canton, leaving his ship at Chuenpe, near the Bogue, and on December 31 the interesting event took place at Pwantang Puntong, a country seat near Canton. The Chinese were represented by Kiying, the three high officials who assisted him in negotiating the treaty, the prefect of Canton, and a large retinue of inferior officers, and the Americans by Biddle, the principal officers of the *Columbus*, Reverends Peter Parker (interpreter) and E. C. Bridgman, Consul P. S. Forbes, and several gentlemen of Canton. After the parties had passed the compliments usual on such occasions, the two ratified treaties were brought forward and were carefully compared. Being found to agree, they were exchanged in due form, Biddle presenting the document ratified by the President and Senate to Kiying, who in turn delivered to Biddle the document ratified by the Emperor; everyone standing during the ceremony. Four copies of a certificate of exchange, previously prepared in both the Chinese and English languages, were then signed and sealed by the commissioners, each of whom retained two copies. After the conclusion of the ceremonies an elaborate Chinese dinner was served in excellent style. Kiying was described by one of the Americans as an exceedingly able and accomplished man, dignified and easy in manner, comparing favorably with "the highest statesmen that can be found in any of the Western courts or cabinets."[19]

As the first treaties with China did not open Peking to foreigners, Canton became the Chinese capital for purposes of diplomatic intercourse between the empire and Occidental countries. The Emperor sent a high commissioner to reside there, and the representatives of the foreign governments lived there or at the neighboring seaports. Biddle established the American legation at the foreign settlement outside the walls of Canton, over which he presided until April 15, 1846, when he transferred his powers as commissioner to Dr. Peter Parker. During his stay in China he visited Amoy, Chusan, Shanghai and Ning-po, dining at the two latter places with the principal mandarins. He reported that the American trade was considerable at Shanghai, but there

[19] Chinese Repository, XIV, 590-591.

was little or none at Ning-po. On July 7 he sailed for Japan, and before the end of the year both ships of his squadron returned home.

Owing to the Mexican War none of our national vessels again visited the Far East until the latter half of 1848, when the ship *Plymouth* and sloop *Preble* arrived in China, being followed early in 1849 by the brig *Dolphin*. This new squadron was commanded by Commodore David Geisinger, another veteran of the War of 1812. He remained in China about a year. When in March, 1849, an outbreak of the populace of Canton was threatening because of the approach of the date fixed for the opening of the city to foreigners, he took measures for the defense of the factories. The opening was postponed and the commotion abated. When in August the Portuguese governor at Macao was murdered under circumstances of unusual atrocity, he landed a small force at that place to protect the Americans and their property. The usual cruises to the Northern ports of China were made, and our commerce at Shanghai was reported to be prosperous and rapidly increasing.

In February, 1850, Geisinger, having been succeeded by Commodore P. F. Voorhees, returned home in the sloop of war *St. Mary's,* which had brought out the new commander-in-chief. After a brief and uneventful tour of duty, Voorhees sailed from China for the United States in August, leaving only one ship on the station, the sloop of war *Marion,* Commander W. M. Glendy. Voorhees's successor, Commodore J. H. Aulick, did not arrive in China until February, 1852.

On the opening of the five treaty ports, our trade with China and the number of Americans residing in that country gradually increased. About 1840 the number of our merchantmen annually visiting Canton was sixty. In 1849 one hundred and three vessels entered the ports of Canton, Shanghai and Amoy. One-fourth of our trade was with Shanghai. The number of arrivals of American ships in China was one-third that of the British, and with the exception of Great Britain greatly exceeded that of any other foreign nation. Immediately after the Opium War there began to appear in Chinese waters long, trim vessels, whose narrowness of beam, sharp lines, tall masts, large spars and heavy weight of canvas appalled the old salts of the trade. These were the China clipper ships, that greatly reduced the time of voyage

between the Occident and the Orient, vying with each other to be the first to deliver the early teas in London and New York. So superior were the first American clippers to their British rivals that they almost monopolized the carrying trade between China and London.[20]

Soon after the Treaty of Wanghia went into effect, American consulates were established at Amoy, Fu-chau, and Shanghai. The first American consul at Hong Kong was appointed in 1843. The first American missionaries in China were the Reverends E. C. Bridgman and David Abeel who arrived at Canton in 1830. When the ports to the northward of Canton were opened to foreigners on the termination of the Opium War, American missions were established there, and the number of missionaries in the treaty ports rapidly increased. The total number of Americans in China, however, was not great. In 1850 it amounted to about two hundred, some thirteen per cent of the Occidental population.

(TO BE CONTINUED.)

[20] Speer, William, The Oldest and Newest Empire, China and the United States, 417-419.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

CONCERNING THE TACTICAL EMPLOYMENT OF TORPEDO-BOATS.*

By Commander L. Vannutelli, Italian Navy.

Translated by Lieutenant H. B. McIntosh, U. S. Navy.

The history of maritime war offers no typical cases of actions between groups of torpedo-boats and ships under way, from which to deduce tactical principles.

To this fact, perhaps, is to be attributed the great diversity of ideas that are generally held upon this important subject.

In the study of such questions as this, eminently practical methods should be employed, rather than simple theoretical analysis. But, on the other hand, when defensive action on the part of the ships is entirely lacking, only a relative value may be assigned to experiments made in time of peace, and even certain exercises of methodical simulated attacks, based only upon special suppositions, may perhaps easily violate tactical criteria, rather than furnish useful experimental data.

And indeed, in analyzing the exercises carried out in time of peace, we encounter, among other circumstances, one in particular; which is, that the torpedo-boats, sure of not running any risk, and of not being disturbed in their maneuvers, follow in the main an exactly prearranged line of conduct, and, in general, the ships do not even attempt to maneuver opportunely for preventing the attack.

Instead, it would evidently be necessary always to suppose that the adversary will not remain passive, but will make the maneuver that seems to him most suitable; this does not exclude the possibility that it might result in situations disadvantageous to him, and he who attacks must be prompt to discern them, and know how to profit by them.

* Revista Marittima Italiana, May, 1910.

The tactics, therefore, should not be rigid, composed of too precise schematic dispositions, but susceptible of adaptation to the special conditions of every single case and to diverse eventualities.

In fact, fortuitous circumstances may give occasion to special tactical initiatives; thus: fog, the moon, the state of the sea, the hydrographic conditions, the conditions of visibility, the positions of the destroyers, the zones illuminated by the search-lights, the contemporaneous discovery of more objectives in different directions, may determine different lines of conduct and have a decisive influence upon the result of the attack.

In order to profit by all these eventualities energetic initiative and quick perception are necessary, but one must not be too much hampered by precise dispositions. Thus, for example: to lose the opportunity of making a good launching solely to maintain oneself in the prescribed geometric formation would be a grave error.

Hence in the attack of a group of several torpedo-boats there is necessary the maximum co-operation among the various units, good mutual understanding, and maneuvering inspired by general principles rather than by prearranged fixed rules, because the line of conduct of each unit will depend upon the manner of directing the rays of the search-lights, upon the firing, upon the maneuvers of the ships, and upon many other unforeseen circumstances.

Therefore, it seems to me fitting to affirm very clearly that certain maneuvers often used during exercises are for the sole purpose of conventional training and have little tactical value.

In short, we must not confound the application of general principles, which may have varied forms, with submission to absolutely rigid rules.

It seems to me that this idea is not sufficiently recognized and emphasized, and that there exists rather a tendency to crystallize into special forms, without keeping well fixed and dominant in the mind those fundamental principles by which one should be inspired in the choice of a line of conduct.

These fundamental principles are certainly well known to all, but, notwithstanding this, perhaps because they were not sufficiently emphasized and very clearly formulated in synthetic manner when passing to examine the practical application, it not infrequently comes to pass that, on account of the diversity of appraisements and habits, the matter ends with the domination of certain systems that are not in complète harmony with the spirit of said principles.

To-day everything tends to establish the belief that with modern anti-torpedo-boat artillery, the torpedo-boats cannot rationally hope to reach the launching distance in the day time; therefore it seems to me that we may at once affirm that the use of the modern torpedo-boat must be limited to the night time, while by day we should rather employ submersibles, whose conditions of invisibility may be said to be ideal.

The anti-torpedo-boat armaments and the characteristics of the torpedo-boats being changed.[1] it follows therefrom that it will be necessary to hold a different idea of their use from that which was held in the past, when, that is to say, the probabilities of hitting and destroying the torpedo-boats with guns were other than at present, the number of the torpedo-boats was also different, and the sacrifice represented by the loss of a certain number of them was much more limited. (In what I shall say I refer specially to sea-going torpedo-boats, armed with three launching tubes, two forward and one aft.)

It seems to me that for the tactical employment of torpedo-boats it would be necessary to be specially inspired by the idea of dispersion of the different vessels of the attacking group, and concentration of their effect.

It does not appear to me either impossible or too difficult to secure the result that the torpedo-boats of the attacking group (provided that the number of units is reasonably limited), conveniently dispersed in order to have the minimum probability of being hit and the maximum probability of not being all discovered at the same moment, may be able to hurl themselves against the target in such a way as to arrive at a launching position simultaneously or at very small intervals, and, therefore, with the maximum probability of useful effect.

Torpedo-boats are very fragile hulls without any defense whatever, which, in order effectively to use their proper weapon, must be able to arrive at a very short distance from the ships, without

[1] The increase in tonnage corresponds to an increase of the general offensive capacity, that is to say, armament, speed, and sea-going qualities. To-day the number of torpedo-boats is smaller, but each one is armed with a greater number of launching tubes. For the present, then, we may expect that in one and the same attack each torpedo-boat may execute several launchings, and that the diverse units of the attacking group may be more widely dispersed. (Author's note.)

having first exercised offensive action, and while the powerful defense of the ships, composed of the guns, is still in full efficiency. It follows from this that the fundamental principle of torpedo-boat tactics must be that of surprise, and, therefore, action in the darkness of the night with several units contemporaneously, but in dispersed order, and at high speeds. And indeed, only the rapidity and impetuosity of the attack and the protection of the darkness can give good probability of arriving in safety at proper launching distance, before the ship is able to discover the attacking vessel and bring its means of defense efficaciously into action.

The simultaneous attack of a proper number of units spread out in the same sector of defense of the ship, cannot but increase the objectives for the firing, thereby rendering concentration impossible and so enormously diminishing the efficacy of the defense, and, vice versa, increasing the probability that some unit of the attacking group may bring the attack to a successful conclusion, and perhaps also without even being discovered, thus effecting a surprise.

When a torpedo-boat is discovered by the ship there is a tendency to concentrate attention upon it; and it is then that the undiscovered boats may profit by their favorable situation, withdrawing from those illuminated by the search-lights and hurling themselves toward the ship across the unlighted zones. However, the number of units that can attack simultaneously is always limited by the necessary dispersion and by the scant amplitude of the space that includes the positions and the profitable launching distances.

The importance of surprise as a factor of success can never be too strongly emphasized; in order successfully to carry it out there is necessary a proper dispersion, and also intelligent co-operation among the various units of the attacking group. For example, there must be no hesitation in sacrificing one's own unit, or in delaying one's own attack, when such a course may insure the success of the maneuvers of the others. Often, therefore, the first boats discovered will be sacrificed, and their action may consist simply in obliging the ship to definitely reveal her position by her own search-lights and gun-fire, or in continuing to draw the fire upon themselves, thus permitting the others to advance together without being discovered.

If, instead, the torpedo-boats of the same tactical group were

used singly and successively, or compactly, there could be no considerable dispersion of the enemy's fire in one and the same sector of offense, and each one would be exposed to immensely greater risks.

Torpedo-boat tactics should be tactics not only of surprise but also of initiative. To obtain this end, if, on the one hand, it is neither profitable nor necessary to have too restrictive fixed forms, on the other hand it is indispensable to maneuver in order and according to definite and uniform general rules. Therefore the order must be understood to be only a means of arranging and conducting the various units prior to the attack in order afterwards to hurl them against the enemy from determined positions.

Summing up, it seems to me that the fundamental principles upon which all torpedo-boat tactics must be based may be said to be the following:

1. Contemporaneous attacks with a proper number of units in such fashion as to have sufficiently scattered order.

2. Attacks regulated in such a way that the various units of the tactical group may arrive at launching position simultaneously, or at very short intervals, without any one of the boats disturbing the maneuvers of any other.

3. Attacks regulated in such fashion that the various units may be found conveniently arranged in case of failure to effect a surprise or when the ship maneuvers to prevent the attack.

4. Attacks inspired by general principles, but not determined by rigid rules. I have already said that the orders are but a means for conducting the various units prior to the attack, and, therefore, they should present characteristics such as to respond, first, to the exigencies of the phase of search and approach preceding the attack, and that then they may permit of easily obtaining the conditions required by the fundamental tactical principles. Every order or formation should present the following requisites:

1. Elasticity, such as to permit sufficient liberty of movement to the various units, and a certain facility for changes of course.

2. Simplicity, so as not to require too much attention to maintaining the formation.

3. Safety, so as to reduce to a minimum the necessity for solicitude about collisions, in case of injuries or variations of speed, and the probability that any unit may disturb the maneuvers of another.

In considering the problem of the formations it is well also to note:

1. That too close formations of attack form a gross compact mass and gross columns of smoke, and facilitate the discovery of the torpedo-boats and the firing against them.

2. That in close formations of attack, or in those in which the various units are upon the same or nearly the same bearing with respect to the ship, it may be said that once the first torpedo-boat is discovered, the others will almost surely be discovered very soon after.

3. Too long formations interfere with mobility, not permitting the rear vessels promptly to see and know what is taking place at the head, the transmission of news and orders being difficult, and they bring to the maximum the intervals of time between the launchings of the different units.

4. In column of vessels, the intermediate units, that have not clear water either ahead or astern, may easily disturb the maneuvers of their immediate neighbors; therefore, in column, especially by night, there is always found a tendency to excessive elongation, and, when the speed is high, there may easily be dangerous closings.

5. The formations should be such as easily to permit the units to follow their respective group leaders, see and imitate their maneuvers without necessity for signals, and easily to permit the closing in of the various units for the transmission of information and orders, etc.

6. Formations should be such as to permit, first, the various units of the tactical group to discover the target simultaneously, and afterwards to dispose themselves easily, in a way to avoid the possibility of one boat masking it from another, to the end that, during the run of approach, all may keep it continually in view, follow its movements, and make a good estimation of the data for pointing.

7. Formations should be such as not easily to permit the smoke of any torpedo-boat to envelop the others—a condition that, at high speeds, is generally met with in a maximum degree, especially in columns of vessels.

8. Formations in which, by night, with lights obscured, each torpedo-boat may easily see another, that is, when the boats present their broadsides to each other, and not their breadths only,

are advantageous for the necessities of nocturnal navigation with lights obscured.

9. Formations should be such as to render easy the subdivision into groups in case of meeting with destroyers, and an opportune maneuver in case of failure to effect a surprise and when the ship maneuvers in time to prevent the attack.

While not holding it to be improbable that torpedo-boats, especially if assisted by a supporting ship (*nave appoggio*), under the normal conditions of darkness of our nights, may be able to make out the larger masses of the ships at a distance sufficient to enable them to arrange themselves in the most convenient form for the attack while approaching to launching distance, it will have to be admitted that very bad cases could present themselves in which the torpedo-boats might find themselves, almost without warning, in contact with the ships in a way that would oblige them to attack in about the same order as that in which they arrive, without having time to arrange themselves very differently. Therefore, the normal formation should not only be such as to be suitable to the period of search for the enemy, but should also lend itself sufficiently to the attack that in the worst cases at least some of the units may be able to attack quickly in the order in which they present themselves.

The problem of formations is intimately connected with the most convenient number of units in the squadron; a number which is limited by the sum total of all the above mentioned exigencies and especially by the matter of assuring the maximum flexibility, facility of maneuvering and transmission of orders; and also by the necessity for subdivision into two groups in order to be able opportunely to envelop the ship in given cases; and by the probability that some of the torpedo-boats may be destroyed by the guns of the ship. This number must not be greater than the limit which permits a proper dispersion and allows all the units of the tactical group to arrive almost together in good position for enabling them to launch almost simultaneously.

It is true that with the increase in number of the units of the tactical group the probabilities increase that at least one unit will arrive at launching distance without being disabled, but it is also true that exceeding a certain limit cannot but increase the difficulties of navigation, the likelihood of confusion and discovery, and above all, and in a maximum degree, the probabilities of the

good effect of the guns of the ships, without returning an adequate increase of practical probability of success for the torpedo-boats.

Let us see what indications concerning this most convenient number can be obtained from consideration of the probabilities of the destruction of the torpedo-boats by the ship.

Let us suppose the time available for firing to be on the average [2] one minute; the practical rapidity of nocturnal fire of modern anti-torpedo-boat calibers [3] to be six shots per minute, which in practice, under the conditions of nocturnal firing against torpedo-boats, can give a probability of hitting of 0.1 for each shot (that is to say, the probable number of effective hits equals 10% with approximation of a fraction less than unity); and that a single good hit is sufficient to disable a torpedo-boat.

The shots that the ship can fire against each torpedo-boat, even under the most favorable hypothesis, are limited in number, and as a single hit suffices to disable the torpedo-boat, it will be necessary to determine the probability of placing at least one shot in the target.

In this special case, the probable number of effective hits considered is minimum, that is, equal to one; therefore, it cannot, with sufficient approximation, be held to be equal to the product of the probability assigned to each shot by the number of shots fired, since this product, being only a result approximating to within a fraction less than unity, would be affected by too great a relative error, and might lead to conclusions unworthy of attention.

Evidently, therefore, in our case, the principle of this product cannot be accepted, since, given the degree of approximation, the exact corresponding value could as well be a fraction less than unity as one. In short, the fact of having ten effective hits out of one hundred shots, does not mean that we may have equal hopes of obtaining one out of ten.

It will then be necessary to have recourse to a rigorous determination, much more exact, by applying the laws relative to recurring events.

[2] See Table 1; but it is considered that it will not always be possible to begin the firing quickly, at 1500 meters, and that the launchings can be executed at distances greater than 500 meters and with angles of impact less than 90°. (Author's note.)

[3] Calibers capable of disabling a torpedo-boat with a single shot. (Author's note.)

If 0.1 is the probability of hitting, the contrary probability for each shot of missing the target will evidently be $1-0.1=0.9$. If the number of shots be n, $(0.9)^n$ will express the total probability of not hitting with all those shots (that is, the event of not hitting is repeated n times), while $P=1-(0.9)^n$ will represent the probability of placing in the target at least one of the series of n shots.

Wishing to determine the number of shots necessary in order to have almost the certainty[4] of being able to place at least one in the target it will be necessary to place the value of P somewhere near unity; for example, let $P=0.90$, and then solve the said equation with respect to n. From this equation we have:

$$n=\frac{\log(1-P)}{\log(0.9)}=\frac{\log(1-0.90)}{\log(0.9)}=21.$$

Hence twenty-one shots must be fired in order to have a 90% probability of placing at least one in the target. And as in the minute of profitable time, each gun can fire six shots, it follows that in order to have good probability of placing one effective hit in each torpedo-boat, it will be necessary to oppose each one with at least four guns, if the boats are in sufficiently scattered order.

But on ships at present in service, each quadrant can be covered by a maximum of ten anti-torpedo-boat guns;[5] therefore, in this view of the case, on each side the number of torpedo-boats that attack simultaneously, provided they are sufficiently dispersed in a way to constitute different targets, should be greater than two.

If, for example, the defense were organized in a way that would enable it to direct the fire of two guns against each torpedo-boat attacking in the same sector, the probability of destroying each torpedo-boat with one hit would be: $1-(1-0.1)^{14}=1-0.2=0.8$; that is to say, the ship would have an 80% probability of destroying each torpedo-boat discovered, and vice versa, each torpedo-boat discovered would have a 20% probability of not being disabled before being able to launch a torpedo.

The lack of practical results based upon extensive experiments induces me to stop with the consideration of the indications sup-

[4] Considering that for the ship there exists the contrary probability of not succeeding in discovering all the torpedo-boats in time, in compensation it should have at its disposal a number of anti-torpedo-boat guns sufficient to assure to it the best probabilities of disabling those discovered. (Author's note.)

[5] We are considering calibers capable of disabling a torpedo-boat with a single effective hit. (Author's note.)

plied by the theory of probabilities, which can give a certain idea (doubtless preferable to none at all) concerning the forecasting of the probable useful effect of artillery in nocturnal firing against torpedo-boats, and limit the field of vague supposition.

I will suppose, for example, that the firing is begun by night against a torpedo-boat at a distance of 1500 meters with guns capable of disabling the torpedo-boat with a single effective hit, and whose rapidity of nocturnal firing is six shots a minute, which is one shot every 10 seconds. It is necessary to distinguish two cases, viz: of firing with fixed sight against a target not illuminated by a search-light, and of firing against a target well illuminated by the search-light and, therefore, permitting sight adjustment, although it may be difficult to accomplish it in practice. Let the relative velocity of the torpedo-boat's approach toward the ship be, for example, 150 meters in every 10 seconds; and let the target offered by the vital parts of the torpedo-boat, the amplitude of which varies according to the way in which it is presented, be on the average,[6] 10 meters in length and two in height.

I will suppose that an error in the sight produces a vertical displacement of the mean point of impact proportional to said error in the ratio of 0.90 meters for every 150 meters of sight error; that the firing is executed with the sight set at 1000 meters in the case of the target not illuminated, and is also begun with the same setting of the sight when the target is illuminated; that a first adjustment of the sights to a distance measured by telemeter cannot be made until after 20 seconds and with an approximation of 50 meters; that the adjustment of the firing may be obtained with three salvos and that it may be maintained thereafter; that the effects of the practical errors of nocturnal gun-laying against targets so movable and so little visible may be represented by mean deviations proportional to the distances, which we will suppose the following: at a distance of 600 meters the vertical equals two meters (corresponding to two-tenths of a degree of error in elevation), and the horizontal equals 10 meters

[6] The mean inclination of the line of sight (see Table 1) with respect to the longitudinal axis of the torpedo-boat is equal to 30°, the length of the vital part of the torpedo-boat is 20 meters, therefore the length of the vital target is 20 sin. 30° = 10 m. (Author's note.)

(corresponding to one degree of error in lateral train),[7] and that they may respectively increase with the increase of the distance in the ratio of 1 meter and 5 meters for every 150 meters of further distance.

Let us see what may be the probable number of shots placed in the target in the two cases cited during the time employed by the torpedo-boat in reaching the distance of 600 meters from the ship (which signifies a launching distance of about 500 meters).

I will consider first the case of the target not illuminated. At a distance of 1500 meters we shall have the first salvo—of n shots if n be the number of pieces—with a sight error of 500 meters which will produce a depression of the point of impact with respect to the center of the target of 3 meters.

Indicating by $P\left(\frac{x}{d}\right)$ the probability of hitting relative to a mean deviation d, and to a size $2x$ of the target, which is the probability of having a deviation less than x, we find that the probability of hitting for each of these shots will be:[8]

$$P=\frac{1}{2}\left[P\left(\frac{3+1}{8}\right)-P\left(\frac{3-1}{8}\right)\right]P\left(\frac{5}{40}\right)=\frac{0.310-0.157}{2}\times 0.076$$

$$=\frac{0.153\times 0.076}{2}=0.005814.$$

And, therefore, the probable number of effective hits for this first salvo of n shots will be (with an approximation of a fraction less than unity):

$$N=n\times 0.005814.$$

For the second salvo made at a distance of 1350 meters, similarly we have:

$$P=\frac{1}{2}\left[P\left(\frac{2.10+1}{7}\right)-P\left(\frac{2.10-1}{7}\right)\right]P\left(\frac{5}{35}\right)=\frac{0.274-0.094}{2}\times 0.088$$

$$=\frac{0.180\times 0.088}{2}=0.00792. \quad N=n\times 0.00792.$$

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[7] We must consider that, especially by night, the center of figure of the visible parts of the torpedo-boat, which is what attracts the attention of the gun-pointer, is always considerably more elevated and laterally displaced with respect to the center of the vital parts which constitute the profitable target; that the time conceded for pointing and firing with the established rapidity of fire is only 10 seconds; that the mobility of the target is considerable and its visibility minimum; that the inevitable variations of intensity of the light of the search-light produce very detrimental effects; that it is not easy to see a torpedo-boat through the port-hole of a redoubt. (Author's note.)

[8] In these calculations I have used the tables and formulas in Alger's *Exterior Ballistics*. (Author's note.)

For the third salvo at the distance of 1200 meters we have:

$$P=\tfrac{1}{2}\left[P\left(\tfrac{1.20+1}{6}\right)-P\left(\tfrac{1.20-1}{6}\right)\right]P\left(\tfrac{5}{30}\right)=\frac{0.225-0.019}{2}\times 0.1$$
$$=\frac{0.206\times 0.1}{2}=0.0103.\quad N=n\times 0.0103.$$

For the fourth salvo at the distance of 1050 meters we have:

$$=\tfrac{1}{2}\left[P\left(\tfrac{0.30+1}{5}\right)-P\left(\tfrac{0.30-1}{5}\right)\right]P\left(\tfrac{5}{25}\right)=\frac{0.163+0.088}{2}\times 0.127$$
$$=\frac{0.251\times 0.127}{2}=0.015938.\quad N=n\times 0.015938.$$

For the fifth salvo at the distance of 900 meters we have:

$$P=\tfrac{1}{2}\left[P\left(\tfrac{0.60+1}{4}\right)-P\left(\tfrac{0.60-1}{4}\right)\right]P\left(\tfrac{5}{20}\right)=\frac{0.250+0.064}{2}\times 0.157$$
$$=\frac{0.314\times 0.157}{2}=0.024649.\quad N=n\times 0.024649.$$

For the sixth salvo at the distance of 750 meters we have:

$$P=\tfrac{1}{2}\left[P\left(\tfrac{1.5+1}{3}\right)-P\left(\tfrac{1.5-1}{3}\right)\right]P\left(\tfrac{5}{15}\right)=\frac{0.492-0.1}{2}\times 0.207$$
$$=\frac{0.392\times 0.207}{2}=0.04572.\quad N=n\times 0.04572.$$

For the seventh and last salvo at the distance of 600 meters we have:

$$P=\tfrac{1}{2}\left[P\left(\tfrac{2.4+1}{2}\right)-P\left(\tfrac{2.4-1}{2}\right)\right]P\left(\tfrac{5}{10}\right)=\frac{0.825-0.424}{2}\times 0.310$$
$$=\frac{0.401\times 0.310}{2}=0.06155.\quad N=n\times 0.06155.$$

Therefore, the total number of probable effective hits during all seven of the salvos will be:

$$n\times[0.005814+0.00792+0.0103+0.015938+0.024649+0.04572$$
$$+0.06155]=n\times 0.171891,\text{ that is, }17\%.$$

When the target is illuminated by the search-light we have a first salvo with the sights set at 1000 meters, with a distance of 1500 meters under the same conditions as those of the first salvo in the case above analyzed, which, therefore, will give the following result:

$$N=n\times 0.005814.$$

Similarly for the second salvo at a distance of 1350 meters, also with the sight set for 1000 meters, we shall have:

$$N=n\times 0.00792.$$

At the third salvo at a distance of 1200 meters the conditions change since the sight will be set for the first measured distance with an approximation of 50 meters; in this case we shall have:

$$P=\tfrac{1}{2}\left[P\left(\tfrac{0.30+1}{6}\right)-P\left(\tfrac{0.30-1}{6}\right)\right]P\left(\tfrac{5}{30}\right)=\frac{0.133+0.088}{2}\times 0.1$$
$$=\frac{0.221\times 0.1}{2}=0.011.\quad N=n\times 0.011.$$

At the fourth salvo at the distance of 1050 meters the error in the setting of the sight is reduced to 25 meters, and we have:

$$P=\tfrac{1}{2}\left[P\left(\tfrac{0.15+1}{5}\right)-P\left(\tfrac{0.15-1}{5}\right)\right]P\left(\tfrac{5}{25}\right)=\frac{0.145+0.106}{2}\times 0.127$$
$$=\frac{0.251\times 0.127}{2}=0.015938.\quad N=n\times 0.015938.$$

At the fifth salvo at a distance of 900 meters the firing is adjusted, and we have:

$$P=P\left(\tfrac{1}{4}\right)P\left(\tfrac{5}{20}\right)=0.157\times 0.157=0.024649.\quad N=n\times 0.024649.$$

At the sixth salvo at a distance of 750 meters, supposing the firing to continue to be adjusted, we have:

$$P=P\left(\tfrac{1}{3}\right)P\left(\tfrac{5}{15}\right)=0.207\times 0.207=0.042849.\quad N=n\times 0.042849.$$

At the seventh and last salvo, supposing the firing to continue to be adjusted, we have:

$$P=P\left(\tfrac{1}{2}\right)P\left(\tfrac{5}{10}\right)=0.310\times 0.310=0.0961.\quad N=n\times 0.0961.$$

Then in this second case the total number of effective hits during all seven of the salvos is:

$$n\times[0.005814+0.00792+0.011+0.015938+0.024649+0.042849$$
$$+0.0961]=n\times 0.204270;\ \text{that is, } 20\%.$$

In practice, when the target is not illuminated, unless the night is exceptionally clear, the errors committed are much greater than those supposed, and, therefore, the percentage of effective hits never amounts to seventeen, but suffers a notable reduction. Similarly, as the immediate and continuous illumination of the discovered torpedo-boat is not always accomplished, and adjusting the firing and following it in the pointing is not easy, nor is it

always possible to illuminate all the torpedo-boats that attack contemporaneously if they are sufficiently dispersed, and to have the intensity of the light constant, the calculated percentage of 20% may be held to be a mean approximating to the truth even admitting that when the target is illuminated the practical errors of pointing may produce errors smaller than those supposed.

Therefore, it appears to me that we may argue that, the number of hits being always small, limiting the percentage of effective hits to 10%, in the general average of the cases, cannot be held to be too pessimistic, since it is also necessary to consider that the above mentioned calculations have been made completely ignoring many other disturbing factors of moral and material nature the influence of which may be enormous.

From what has been said it appears that the principle of the dispersion of the various simultaneously attacking torpedo-boats is also imposed in order to avoid having several of them illuminated at the same time by the same search-light, which would bring about a condition immensely advantageous for the firing.

In general, ships at present in service have not more than four search-lights on each side, so that the number of torpedo-boats that, being sufficiently dispersed, can be illuminated at one and the same time, will be, at the maximum, four on each side.

Excessively increasing the number of units in the attacking group means the abandonment of that proper dispersion which can give good probabilities of success in the surprise, and the assemblage of too many units crowded together in excessively compact order in the limited space included by the distances and the proper positions for launching;[9] which is not well since, even without preoccupying oneself with the amount of the losses, one must take into consideration the moral effect and the disorganization produced by the sinking of units very close to each other.

Under the present conditions of launching distances, angles of impact, etc., it is held in general that the most convenient number of units of the squadron is four, or at most six; and many think that the tactical unit should be the half squadron, that is to say, the section; and this answers to the idea of action in subdivided groups, which is imposed in case the ship maneuvers to avoid the

[9] The angular amplitude of this space diminishes with the increase of the ship-torpedo speed ratio. (Author's note.)

attack. (It is said that the Japanese attacked in groups of two units; Labrès upholds groups of three units each.)

Some nations, as France, Germany and the United States, add to the squadron a unit of greater tonnage, that is to say destroyers, which, having greater scouting efficiency, can conduct the two sections of torpedo-boats and at the same time contribute either to the attack on the ship as a torpedo-boat or to the defense against destroyers.

The best conditions for the maneuver of attack of the torpedo-boats must be determined by necessities of a different nature and by their opportune combination, that is, with respect to the gun in a way to have the minimum probability of being discovered and hit, and with respect to the launching, in a way to have the maximum probability of hitting the ship. As regards the manner of confronting the fire of the ship it is necessary to consider:

1. That ships, in nights of normal darkness, cannot hope to succeed in sighting torpedo-boats at a distance greater than a mile.

2. Experience has demonstrated that by night, firing with rapid-fire guns, at a taget 6 meters long and 2.20 meters high, there is rarely obtained a percentage of effective hits greater than 3%. Lieutenant Dewar, speaking of experiments carried on in England, cites a result of only 6 shots placed in the target out of 128 fired with guns of 76 mm., with a firing distance a little greater than the normal launching distance.[10]

3. That the time in which a torpedo-boat remains exposed to fire before arriving at launching distance is very short, that is, about one minute.

Supposing the firing to be begun on an average at a distance of 1500 meters, the ship's speed to be 14 knots, the speed of the torpedo 34 knots, and the launching distance 500 meters, the times during which the torpedo-boat remains exposed to fire and the variation of distance and bearing for each interval of 10 seconds, for the two extreme cases, of attack on opposite courses at a lateral interval of 500 meters and attack with a normal approach, and an angle of impact of 90° in both cases, are shown in the following table:

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[10] It would be greatly interesting to make lengthy experiments in night firing with the ship in motion against a target towed at high speed and which is presented by surprise. (Author's note.)

TABLE I.

Speed of torpedo-boat = 20 kts. Speed of ship = 14 kts. Speed of torpedo = 34 kts. Launching distance = 500 meters. Angle of impact = 90°.

Times of firing.	Attack when on opposite parallel courses.		Attack on a normal course.	
	Distance torpedo-boat to ship.	Bearing from ship's head.	Distance torpedo-boat to ship.	Bearing from ship's head.
Seconds.	Meters.		Meters.	
0	1500	19° 30′	1500	60°
10	1342	22°	1387	60° 10′
20	1185	25°	1265	60° 30′
30	1032	29°	1142	60° 40′
40	890	35°	1025	61° 30′
50	752	41° 30′	900	62° 30′
60	635	51° 30′	780	63° 30′
70	547	66°	660	65°
71.5	540 (Launch)	68°	....	.....
80	....	.....	540 (Launch)	68°

NOTE.—In case of attack on a normal course no account is taken of the change of course that it may be necessary to make in order to execute the launching if there are no bow launching tubes or torpedoes with angle gyroscopes. (Siluri angolati.)

It results from this table that in case of attack on a normal course the torpedo-boat remains continually, during the 80 seconds, in the sector of 60° forward of the ship's beam, that is to say, in the sector of maximum offense; while in the case of attack on a parallel course it enters it only after the first 30 seconds, remaining therein 41 seconds. Moreover, it is shown that the depth of the target exposed by the torpedo-boat to the fire of the ship, determined by the inclination of the line of fire to the longitudinal axis of the torpedo-boat, an inclination that is equal to the bearing given in the table in the case of the parallel course, and to its complement in the other case considered, is greater on the parallel course during the first 30 seconds, while afterwards it becomes continually and rapidly greater in the attack on the normal course.

4. That the probabilities of hitting with the guns increase with the increase in compactness of the formations of attack; since, when the torpedo-boats are in very close order, they almost constitute a single very extended target, easily visible, and, vice versa, they diminish with the increase of the dispersion of the torpedo-boats in the same sector and in a direction normal to the line of fire.

5. That the same probabilities increase with the increase in depth of the formation of attack in the direction of the bearing from the ship, so that they are at maximum when the various units keep themselves on or near the same bearing with respect to the ship, thus remaining exposed to an enfilading fire.

6. That the same probabilities increase if the torpedo-boats make considerable changes of course; since, in that case, the relative rapidity of movement greatly diminishes. In fact, even torpedo-boats that have the best maneuvering qualities, in order to complete the first 90° of change of course, occupy not less than 35 seconds at full power, and during that time their change of position is minimum.

I have forborne to cite all the other well known conditions that determine the probability of hitting a torpedo-boat with the gun; such as, the time during which it remains exposed to fire, sectors of maximum offense, distance and rapidity of change of bearing.

In a typical attack of torpedo-boats we may distinguish three successive phases:

1. The getting into contact by making out the ships; 2, the maneuver for taking up good position for launching; 3, the execution of the launching.

It is not necessary to believe that, in our waters and with modern torpedo-boats, in which the lookout is sufficiently elevated, on a night of normal obscurity and when in a good situation with respect to the land, the eventuality of sighting the larger masses of the ships, especially if they are grouped together, before the ships can discover the torpedo-boats, must be held to be a fortunate circumstance and very improbable. Experience has demonstrated that while ships, under the most favorable conditions, cannot hope to make out torpedo-boats at a distance greater than one mile, even when the destroyers have signalled their approach, on the contrary, torpedo-boats stand a good chance of making out ships between two and three thousand meters away.

The torpedo-boats that are successful in evading the destroyers and passing through their line, having seen the search-lights or the vague and confused black masses of the ships, will approach still nearer in order the better to make them out and to ascertain the direction in which they are moving, and then perhaps withdraw again, if necessary, and move ahead in order to take up favorable positions for launching.

Let us then consider the conditions of launching. In this connection it is necessary to note:

1. The launching tubes, in one and the same attack, can execute only one launch each against the enemy, being afterwards exposed to almost certain destruction; therefore, in their use great care must be taken to put them in conditions for having good probabilities of hitting.

2. Notwithstanding the increase in speed of modern torpedoes, launching from great distances against moving ships cannot be held to be of use, since it is difficult to estimate the data for pointing, that is to say, the speed and course of the enemy, and with the speeds of present torpedoes the influence of errors in the speed and course of the enemy cannot yet be said to be negligible.

3. Generally the speed of the enemy may be more accurately estimated than the course. In this connection it must be considered that, for an observer sufficiently distant, the profiles of two ships that are following directions almost symmetrical with

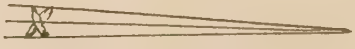


Fig. 1.

respect to the normal to the mean line of sight, are the same, as indicated in the figure. Expert observers can estimate the speed of a ship with an approximation of about three miles, and the course with an approximation of about 20°.

4. The probability of hitting with the torpedo increases with the diminution of the launching distance, which, however, should never be less than 100 meters to the end that the torpedo may have time to regulate its course. The poor results obtained with the torpedo by the Japanese in the last war are to be attributed principally to the fact that they desired always to use the torpedo at the extreme limit of its range and, therefore, often finished by launching at too great distances.

5. The opportune launching distance diminishes with increase of speed of the target; therefore, as the speed of the ship increases, it will be well to diminish the launching distance.

6. Keeping the ratio between the speed of the target and that of the torpedo not greater than one-half, as is to-day practically the case, the probability of hitting a target of the dimensions of an ordinary ship, and which, therefore, presents an exposed surface

which varies with the inclination of the trajectory of the torpedo to the course of the ship, that is to say, the angle of impact, is maximum for an angle of impact of 90°, and remains very good as far as an angle of impact of 30°,[11] while it rapidly diminishes as soon as the said angle becomes greater than 90°, as is indicated in Table 2.

TABLE 2.

NUMBERS PROPORTIONAL TO THE PROBABILITY OF HITTING WITH THE TORPEDO.

Angle of impact.	Ratio between the speed of the target and that of the torpedo.		
Degrees.	½	⅓	¼
0	3.88	4.61	5.40
10	3.58	4.27	5.03
20	6.42	7.83	9.29
30	8.52	10.75	13.00
40	9.89	13.18	16.22
50	10.68	15.10	19.14
60	11.09	16.87	22.03
70	11.34	18.65	25.16
80	12.91	21.05	29.42
90	**12.98**	**25.14**	**36.26**
100	7.90	16.48	24.58
110	5.17	11.51	17.69
120	3.55	8.37	13.14
130	2.50	6.14	9.87
140	1.78	4.52	7.38
150	1.24	3.22	5.34
160	0.81	2.12	3.56
170	0.41	1.09	1.84
180	0.44	1.16	1.96

NOTE.—The above table was calculated by P. R. Alger on the basis of actual conditions, that is to say, a target not represented by a geometrical point, but having dimensions and consequently an exposed surface that varies with the angle of impact.

7. The same probability of hitting with the torpedo (supposing the speed of the torpedo to be not less than 34 miles) is sufficiently good up to distances not greater than 700 meters (41 seconds of run with a speed of 34 miles), while it rapidly diminishes at greater distances.

8. The launching distance is also limited by the action of avoiding the possibility that the ship, during the run of the torpedo,

[11] Supposing the angle of impact counted from 0° to 180° to be reckoned from the bow. (Author's note.)

may have time to execute a change of course sufficiently wide to enable it to avoid the torpedo, or to render the angle of impact so small as to exclude the possibility of the functioning of that weapon. Under the actual conditions of speed of torpedoes and with the present maneuvering qualities of ships (about 80 seconds of time being necessary in order to complete the first 90° of change of course) it is not advisable, even in the most favorable case, to launch at distances greater than 700 meters (41 seconds of run).

TABLE 3.

MAXIMUM DEVIATIONS WITH RESPECT TO A TARGET REPRESENTED BY A GEOMETRICAL POINT.

Calculated on the basis of the following data:

Speed ratio torpedo to target = 2.

Error in estimation of target's speed = 1/10.

Error in estimation of target's course = 1/5 (that is, about one point, 11¼°).

In the table it is supposed that the two errors produce deviations in the same direction, the worst case.

Bearing at the instant of launching, counted from the head of the target.	Distances in meters.		
	500	750	1000
Degrees.	Meters.	Meters.	Meters.
0	33	50	67
10	36	54	72
20	39	58	77
30	41	62	82
40	43	65	86
50	45	67	89
60	45	67	90
70	44	66	87
80	38	57	76
90	33	50	67
100	49	73	98
110	65	97	129
120	80	120	159
130	92	138	184
140	102	153	204
150	108	162	216
160	109	164	219
170	107	161	213
180	100	150	200

NOTE.—This table was calculated by P. R. Alger considering the deviation to be the distance between the target and the torpedo at the moment when the line joining the target and the torpedo is normal to the trajectory of the torpedo.

9. An angle of impact of 30° is sufficient to insure the functioning of modern torpedoes. And I insist upon the fact since it seems to me that there continually exists a tendency to exaggerate the importance of an excellent angle of impact to the detriment of so many other indispensable conditions for enabling one to have good probability of arriving in position and in condition to execute the launching of the torpedo.

10. Launchings executed at excessive distances, beyond the range of the torpedo, may also be effective, thanks to the speed of the ship, when, the angle of impact being less than 90°, the ship in its movement advances toward the torpedo and has a component of speed which is to be added to that of the torpedo; while the error in distance may more easily prevent the torpedo from arriving at the target, if the angle of impact is greater than 90°.

11. While for a torpedo-boat situated in a sector sufficiently forward of the ship's beam the run of the torpedo is always less than the distance from ship to torpedo-boat at the moment of launching, for a torpedo-boat situated in a sector abaft the beam the opposite is the case.

12. The pointing in launchings executed on the change of course is less difficult than is supposed, since one is prepared for the angular movement, which is uniform, while in pointing with a constant course one may, especially with flat hulls, have occasional easily sensible yawings.

13. The estimation of the speed of the target and the launching distance is much more easy when the course of approach of the torpedo-boat is normal to the course of the target than when it is the contrary.

14. The launchings of the various units should always be made from positions such as to exclude the possibility of the torpedoes on their proper courses being run into by the torpedo-boats.

15. The probabilities of hitting increase when the different units of the attacking group maneuver so as to execute simultaneous or nearly simultaneous launchings, which present possibilities of the compensation of errors and give the same advantages recognized in salvos of artillery. If p is the probability of hitting with each single launching, $P = 1 - (1 - p)^n$ will be the probability of hitting with at least one torpedo when the number of the launchings is n, and p being always nearer to zero than to unity, evidently P will always be considerably greater than p.

16. The principles of probability applied to torpedo launchings can give us a certain approximate idea of the relative value of launchings executed under different conditions.

Let us suppose that the mean error in the estimation of the speed of the target is, at the maximum, $\frac{\Delta V}{V} = \frac{1}{3}$; that the error in the estimation of the course is, at the maximum, $\Delta R = \frac{1}{2}$ (or about 30°, unity representing a radian); that the speed ratio of ship and torpedo is $\frac{1}{2}$; and that the distance from ship to torpedo-boat at the instant of launching is 600 meters.

I will first consider an intermediate launching position situated in the zone of the more advantageous positions, corresponding to the bearing of torpedo-boat from ship of 40°, that is, to an angle of impact of about 60°.

From the accompanying Table 4 we take the deviations due to the two errors in the estimation of the speed and of the course, which, with the established data, give the following:

$D' = 600 \times \frac{1}{3} \times 0.2558 = 51.16$, that is to say about 50 meters.

$D'' = 600 \times \frac{1}{2} \times 0.3042 = 91.26$, that is to say about 90 meters.

Therefore, the mean value of the total mean deviation resulting from these two independent deviations will be:

$\sqrt[2]{50^2 + 90^2} = 102$ meters, that is to say about 100 meters.

Passing to the consideration of the case of launching from the less advantageous position in the zone further astern, corresponding to angles of impact greater than 90°, taking for example the intermediate position corresponding to ship-torpedo-boat bearing of 90° (symmetrical with that corresponding to 60° already considered), that is, to the angle of impact of 120°, we have for the value of the mean deviation about 130 meters.

Having considered the cases of mean angles of impact of 60° and 120°, if the ship is 100 meters long the normal surface of target exposed will evidently be:

$100 \times \sin 60° = 100 \times 0.866 = 86.6$; about 80 meters.

With mean deviations of 100 and 130 meters, the probabilities P and P' of hitting a target 80 meters long, that is to say, of having a deviation less than 40°, are (using Alger's tables):

$$P\left(\frac{40}{100}\right) = 0.250, \text{ or } 25\%.$$

$$P'\left(\frac{40}{130}\right) = 0.18, \text{ or } 18\%$$

But I have already said that if, for example, against every torpedo-boat the ship can direct the fire of two guns, under the conditions established on pages 13 and 14, every torpedo-boat discovered by the ship at a distance of 1500 meters will have a 20% probability of arriving at launching position without being disabled. Therefore, the total probability of realizing this condition and at the same time the other one of hitting with the torpedo (I am considering that the torpedo-boat makes but one launching), will be for every single torpedo-boat discovered, the following, in the two cases considered:

$$0.20 \times 0.25 = 0.05 \text{ or } 5\%. \quad 0.20 \times 0.18 = 0.036, \text{ or } 3\%.$$

If the torpedo-boats concurring in the attack were three in number, sufficiently dispersed to constitute different targets, and should all three succeed in launching their torpedoes, and the three launchings were executed under the same conditions, that is to say simultaneously, neglecting the small differences due to slightly different angles of impact, and admitting the same conditions established above, the probability of hitting the target with at least one of the three torpedoes would be, for the two cases considered:

$$1-(1-0.25)^3 = 1-0.421875 = 0.578125, \text{ or } 57\%.$$
$$1-(1-0.18)^3 = 1-0.6 = 0.4 \text{ or } 40\%.$$

Hence the enormous advantage of launching simultaneously clearly appears. But for each of the three torpedo-boats that attack together the probability of not being hit by the guns is 0.20, and, therefore,

$$1-(1-0.20)^3 = 1-0.5 = 0.5,$$

expresses the probability that at least one of the three units discovered by the ship will arrive at launching position without being disabled.

And finally the total probability that besides this condition there may at the same time be also realized another, that the fortunate torpedo-boat that succeeds in launching its torpedo may hit the ship, will be the following for the two cases considered:

$$0.5 \times 0.25 = 0.125 \text{ or } 12\%$$
$$0.5 \times 0.18 = 0.090 \text{ or } 9\%.$$

TABLE 4.

Bearing of torpedo-boat from ship's head at the instant of launching.	Angle of the trajectory of the torpedo with said bearing.	$\frac{D_1}{S\frac{\Delta v}{v}}$	$\frac{D_2}{S\Delta R}$
Degrees.	Degrees.		
0	0°	.0	.3333
10	4° 59′	.0586	.3321
20	9° 51′	.1193	.3278
30	14° 29′	.1843	.3193
40	18° 45′	.2558	.3042
50	22° 31′	.3329	.2799
60	25° 40′	.4174	.2410
70	28° 02′	.5053	.1839
80	29° 30′	.5649	.0996
90	30° 00′	.6667	.0
100	29° 30′	.7221	.1273
110	28° 02′	.7482	.2723
120	25° 40′	.7379	.4260
130	22° 31′	.6881	.5776
140	18° 45′	.6031	.7175
150	14° 29′	.4828	.8362
160	9° 51′	.3370	.9258
170	4° 59′	.1700	.9820
180	0°	.0	1.0000

$$\frac{\text{Ship's speed}}{\text{Torpedo's speed}} = \frac{1}{2}$$

D_1 = Deviation due to error in estimation of the speed.

D_2 = Deviation due to error in estimation of the course.

S = Distance from ship to torpedo-boat at the instant of launching.

$$\frac{\Delta v}{v} = \frac{\text{error in estimated speed}}{\text{ship's speed.}}$$

ΔR = Error in estimated course expressed in circular measure.

NOTE.—This table was calculated by Alger.

So that, under the above mentioned conditions—which are anything but optimistic—in the simultaneous attack of three torpedo-boats that are discovered by the ship, all at the same time, at a distance of 1500 meters, and are sufficiently dispersed to constitute different targets, launching at a distance of about 600 meters with a mean angle of impact of 60°, we may expect a 12% probability that at least one will succeed in launching a torpedo and hit the ship with it, while if the mean angle of impact were 120° there would be only about 9% of probability.

Admitting that we may have a 60% probability that at least one of the torpedo-boats of the attacking group will succeed in reach-

ing the launching position undiscovered, and thus surprise the ship, let us determine what should be the minimum number of groups of three units each, that must attack the ship from advantageous positions, supposing that all the attacks are made under the same conditions, in order to have, even with the torpedo-boats discovered and exposed to fire, a 40% probability of success against the ship.

If the probability of success for the attack of a single discovered group is 12%, evidently we shall have:

$$n=\frac{\log(1-0.4)}{\log(1-0.12)}=\frac{\log 0.6}{\log 0.88}=\frac{\bar{1}.7782}{\bar{1}.9445}=\frac{0.2218}{0.0555}=4;$$

that is to say, against each ship there should be hurled at least four groups of three units each.

At this point the question spontaneously presents itself whether, having four sections of three units each, so as to be able to hurl to the attack two of them on each side of the ship, it would be well to make simultaneous attacks with the two sections on the same side so arranged that one of them may be in a position further astern than the other with respect to the ship, as indicated in Fig. 7, or successive attacks, both of them from advantageous positions, as shown in Fig. 6.

The probability of success for an attack of a group of three units, executed from an advantageous position (mean angle of impact=60°) is 12%, and the relative probability for a similar attack from the position further astern (angle of impact=120°) is 9%; therefore, the total probability for these two simultaneous attacks will be 12+9=21%.

If, on the other hand, the two attacks were successive and both from the advantageous position, the ship could increase the number of guns directed against each torpedo-boat, after having ascertained that the attack is made in a single sector; for example, after 20 seconds, that is at the fourth salvo, there could be concentrated in the forward sector a part of the guns destined for the defense of the after sector. In this case, therefore, if at the fourth salvo the fire of three pieces could be directed against each torpedo-boat instead of two as at first supposed, the probability of success for each of the two successive attacks would be:

$$1-(1-0.1)^{18}=1-(0.9)^{18}=1-0.149=0.851$$
$$1-(1-0.149)^{3}=1-0.616=0.384$$
$$P=0.384\times 0.25=0.096.$$

And as a total for the two successive attacks we should have:

$$0.096 \times 2 = 0.192 \text{ or } 19\%.$$

This shows that there is about the same probability of success in the case of the simultaneous attack of the two groups as in the case of successive attacks. In practice the advantage of the successive attacks from favorable positions for launching increases, since, evidently, the guns destined for the defense of the after sectors of the ship cannot direct their fire on the torpedo-boats that present themselves in the forward sectors after only 20 seconds as has been supposed.

17. In attacks on opposite parallel courses the launching tubes can be trained ahead up to the maximum angle, equal to the minimum angle of impact admissible, while in attacks on normal courses it will be well to keep the forward tubes at the maximum angle of chase thereby to render minimum the change of course necessary for launching.

18. If it is true that launching at short distance increases the probability of hitting, it is also true that in waiting to arrive at short distance one risks being sunk and not launching at all. So that it seems to me that for torpedo-boats that have several launching tubes, and that are advancing under fire, it may be better to execute the first launch at a distance not the minimum, which gives sufficient probability of hitting, and the others at shorter distances.

The most convenient launching distance for a torpedo-boat discovered, and, therefore, exposed to fire, should be established on the basis of the probability of not being disabled by gun-fire and of the probability of hitting with the torpedo, if these probabilities could be known with sufficient approximation.

Evidently the first probability diminishes with the diminution of the distance while the second increases, and, therefore, the most convenient launching distance will be that corresponding to a maximum of the total probability that expresses the contemporaneous realization of these two happenings.

In order to have some idea—if not an exact one, certainly less vague than none—of the relative value of the various launching distances, we turn to the first example cited on page 1111 from which it results that $n \times 0.17$ is the number of hits effective against torpedo-boats during the time employed in arriving at the distance of 600 meters from the ship, if the number of guns directed against it is n.

Similarly from the same example we find that the number of effective hits in the time necessary for arriving at the distances of 750, 900, 1050 and 1200 meters are, respectively:

$$n \times 0.11,\ n \times 0.06,\ n \times 0.03,\ n \times 0.02.$$

If the number n of the guns directed against each torpedo-boat were equal to two, we find that, in the times employed in reaching the distances considered, the probabilities of placing at least one shot in the torpedo-boat are as follows:

At the distance of	600	meters	P'	$= 1-(1-0.17)^{14}$	$= 1-0.073$
" " " "	750	"	P''	$= 1-(1-0.11)^{12}$	$= 1-0.247$
" " " "	900	"	P'''	$= 1-(1-0.06)^{10}$	$= 1-0.538$
" " " "	1050	"	P''''	$= 1-(1-0.03)^{8}$	$= 1-0.783$
" " " "	1200	"	P'''''	$= 1-(1-0.02)^{6}$	$= 1-0.885$

and vice versa, the probabilities of reaching the said distances without being disabled will be for the torpedo-boat:

For the distance of	600	meters	$= 0.073$
" " " "	750	"	$= 0.247$
" " " "	900	"	$= 0.538$
" " " "	1050	"	$= 0.783$
" " " "	1200	"	$= 0.885$

Supposing that, with a mean angle of impact of 60° (ship's speed = ½ torpedo speed; the angle of impact of 60° corresponds to the ship-torpedo-boat bearing of 40°), the mean practical deviations relative to the launching are, respectively, 100, 200, 300, 400 and 500 meters for the distances considered, the probabilities of hitting a target whose exposed surface normal to the trajectory of the torpedo is 80 meters (angle of impact 60°) will be represented in the following manner:

For the distance of	600	meters	$P\left(\frac{40}{100}\right)$	$= 0.250$
" " " "	750	"	$P\left(\frac{40}{200}\right)$	$= 0.127$
" " " "	900	"	$P\left(\frac{40}{300}\right)$	$= 0.082$
" " " "	1050	"	$P\left(\frac{40}{400}\right)$	$= 0.064$
" " " "	1200	"	$P\left(\frac{40}{500}\right)$	$= 0.04$

Therefore, the total probabilities relative to the contemporaneous realization of the two happenings of not being hit by the guns and of hitting with the torpedo, will be:

For	the	distance	of	600	meters $= 0.073 \times 0.025 = 0.01825$
"	"	"	"	750	" $= 0.247 \times 0.127 = 0.03136$
"	"	"	"	900	" $= 0.538 \times 0.082 = 0.04411$
"	"	"	"	**1050**	" $= 0.783 \times 0.064 = \mathbf{0.05011}$
"	"	"	"	1200	" $= 0.885 \times 0.04 = 0.03540$

These data give us to understand that the most advantageous ship to torpedo-boat distance for launching with a mean angle of impact of 60°, considered in regard to the profitable effects of the gun and of the torpedo, is about 1050 meters, corresponding to a launching distance of

$$1050 \times \frac{\sin 40^\circ}{\sin 120^\circ} = 1050 \times 0.74 = 777 \text{ or about 750 meters.}$$

19. It seems logical to me that the torpedo-boats which have several launching tubes should increase the probability of hitting the target by launching from all the tubes rather than economize torpedoes with the grave risk of carrying them to the bottom along with themselves.

20. In order to diminish the probability of being discovered it will be necessary to guard against the possible emission of flame and too much smoke from the funnels, and, therefore, it cannot be said to be well to force the speed too much before being discovered.

After what I have said it seems evident to me that, without going further, we may establish the following:

1. That on the basis of the considerations above set forth, the most convenient positions for starting for an attack are, from all points of view, those included in the two quadrants forward of the ship's beam, and corresponding to an angle of impact not greater than 90°; a fact well known to all. It follows from this that it will always be desirable to gain a position sufficiently forward of the beam before starting on the attack.

2. That, without doubt, it is to be held convenient to attack successively with several squadrons and contemporaneously from both sides of the ship, or, according to the possibilities, successively at intervals from one and the same side, etc. . . . . , but it will never be advisable to abandon the proper dispersion of the units of the same squadron or section. Attacks conducted from

both sides of the ship simultaneously greatly disconcert the ship, and, given the natural tendency to follow the first torpedo-boats discovered, attacks at successive intervals present the probability of having a certain number of torpedo-boats which may arrive undiscovered at position for launching while attention is entirely directed to the preceding ones already discovered.

It is clear that the position for launching against a ship underway, with an angle of impact not greater than 90°, nearest the beam that a torpedo-boat can occupy in the forward quadrants, is that which corresponds to a torpedo's track normal to the course of the ship; and, therefore, the angle, reckoned from the ship's head,

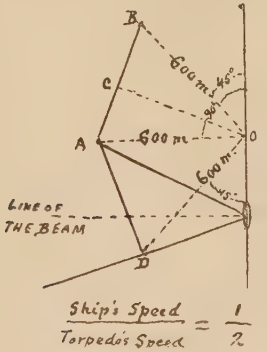


FIG. 2.

which includes all the positions advantageous for launching, depends upon the ship-torpedo speed ratio. Supposing this ratio to be not greater than one-half—as is the case in practice—the zone of the positions most favorable for launching is included in the angle of about 60°, whose cotangent is equal to one-half.

Always supposing the ship-torpedo speed ratio to be not greater than one-half, the condition that the mean run of the torpedo must be 600 meters, together with the other condition that the angle of impact cannot be greater than 135°, determine the extreme position that a torpedo-boat may occupy in the after quadrant of a ship in order to execute the launching. (See Fig. 2.)

Solving the triangle formed by the track of the torpedo having an angle of impact of 135° and the contemporary track of the ship (speed ratio $=\frac{1}{2}$) we find that the aftermost position of the attacking torpedo-boat can be, at the maximum, that which cor-

responds to a bearing of 107° from the ship's head, which is not more than about 20° abaft the beam.

Hence we may distinguish two zones profitable for launching; the most advantageous limited by the said angle of 60°, and the other corresponding to angles of impact greater than 90°, which extends as far as 20° abaft the ship's beam.[12]

This being laid down let us pass to examine the most important and culminating moment of the attack, which is that of launching the torpedo, thence to deduce from the sum total of the conditions set forth what may be the best disposition of the different units of the squadron for the execution of the launching, which is the final object toward which all must strive and to the good result of which all must sacrifice.

I have already said that the ideal conditions towards which it is necessary to tend are dispersion of the different units and concentration of their offense; only in this way can we have good hopes of success in the surprise and of enormously increasing the total probabilities of hitting with simultaneous launchings, probabilities that for each single launching considered alone are minimum.

It follows from this that the various units of the tactical group should arrive contemporaneously in position for launching.

But the space that includes the positions profitable for launching is determined not only by the sector of 60° forward of, and 20° abaft the beam of the ship, but also by the limitations of the angle of impact which I will set down at 45° on one side and 135° on the other, and by the mean distance convenient for launching which I establish at 600 meters.

The different units of the same tactical group should, therefore, under the best conditions, arrive contemporaneously on the arcs AB and AD (Fig. 2). Considering, instead of the arcs, the chords of the arcs, which differ very little from them, it is evident that the lines of maximum length along which the torpedo-boats may be dispersed in order to occupy contemporaneous positions for launching are $AD = AB = 2BC = 2 \times 600 \times \sin 22° = 600 \times 2 \times 0.37 = 444$.

Hence the maximum length of the arrangement in scattered

[12] If the ship-torpedo speed ratio could be kept less than ½ the angular extension of the zones profitable for launching would be greater. (Author's note.)

order which permits concentration of launchings is about 400 meters on each of the aforesaid lines. And as, for the principle of dispersion, it cannot be said to be convenient to close too much the distances between the various units that join in the simultaneous attack, it seems to me that the number of the said units can never be greater than three for each of the two lines. It is concluded then that we may affirm that the squadron can, at the maximum, be composed of six units, and that the tactical unit must be the section; in this connection I mention again that it

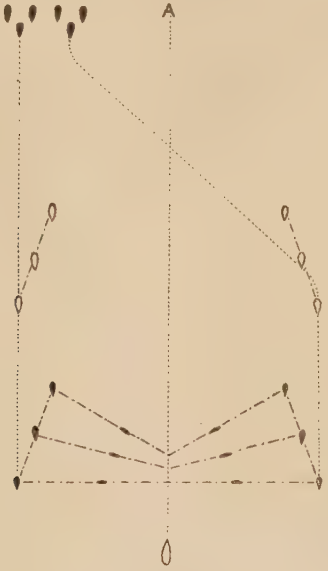


FIG. 3.

appears that the Japanese at times attacked successively by sections composed of two units each (see "The Truth about Port Arthur," page 99, line 17), and that Labrès establishes as the tactical unit the group formed of three torpedo-boats.

The lines *AB* and *AD* of the formation not only respond to the principle of the concentration of the launchings, but for the most part are also excellent lines of dispersion for confronting the fire of the guns, being nearly normal to the lines of fire.

The torpedo-boats dispersed along the most advantageous line *AB* can have various courses whose extreme limits are, on the one side, courses opposite to that of the ship, and on the other, courses normal thereto.

The first case, with opposite parallel courses, is doubtless the most advantageous because it permits the maximum relative swiftness of approach and keeps the torpedo-boats, as is seen from Table 1, for about half the time in the ship's sector of minimum offense; therefore, wherever possible, it should always be preferred,[13] also because, in night attacks, whatever maneuver the ship may make, the two sections, being separated, can always oppose it with the opportune counter maneuver. In this case it must be held to be best to envelop the ship, attacking with the two separated sections from both sides at once (Fig. 3).

This form of attack, by sections on both sides, is specially advantageous when the ship, having made out the torpedo-boats when sufficiently far away, may have time to maneuver. The two most convenient maneuvers for the ship are the following: either to head directly toward one of the torpedo-boats (Fig. 4), probably the first one discovered, and turn toward it in a way to keep it always directly ahead (the torpedo-boat remains continually in the ship's sector of minimum offense), or to turn with the helm hard over (Fig. 5) so as to try to leave the torpedo-boats astern,

[13] Considering a ship that has an extreme forward sector of 30° covered by three anti-torpedo boat guns, and the sector of 60° forward of the beam covered by $3+3=6$ guns (rapidity of night firing six shots a minute) and admitting that in the attack on opposite parallel courses the torpedo-boats (see Table 1) may be during the first four salvos in the aforesaid sector of 30°, and in the attack on a normal course they may always be in the said sector of 60°, we see that if the number of the boats attacking simultaneously is three, each one might be exposed to the fire of a single piece in the first phase of the attack on the parallel course, and to that of two pieces in the second phase; while in the attack on a normal course each will always remain exposed to the fire of two pieces. Therefore the total number of shots fired at each torpedo-boat in the available minute of time will be:

For the attack on the parallel courses = 12 (time of firing 71 seconds).
For the attack on the normal courses = 18 (time of firing 80 seconds).

Admitting that in the firing one may expect 10 per cent of effective hits, the probability of disabling each torpedo-boat with one hit is:

For the parallel courses, $P=1-(1-0.1)^{12}=1-0.28=0.72$
For the normal courses, $P=1-(1-0.1)^{18}=1-0.15=0.85$

Hence the probability of arriving at launching position with an angle of impact of 90° and without being disabled is represented by 0.72 for the parallel courses and by 0.85 for the normal courses; so it appears that the difference is not so great as at first might have been supposed. (Author's note.)

that is to say, in a disadvantageous position for launching. Considering that the ship occupies 80 seconds in completing the first 90° of the turn, and that the distance of good and clear discovery cannot, for the ship, exceed 1500 meters, Fig. 5 indicates how, with an opportune maneuver, and with sufficient intervals between the different torpedo-boats, a part of the units of each group could always be in good position for launching. This, however, is one of the critical cases that requires the greatest amount of

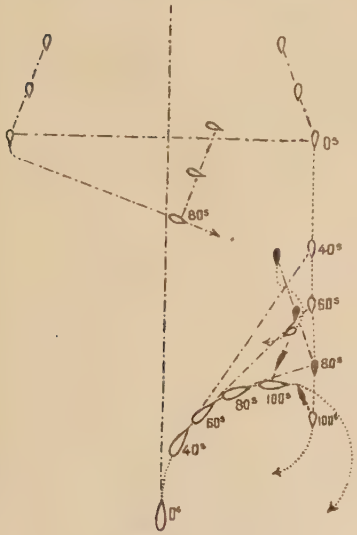


FIG. 4.

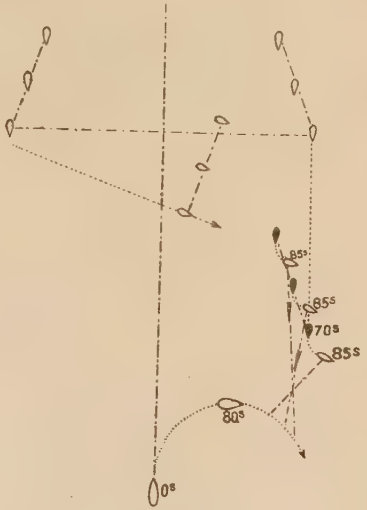


FIG. 5.

co-operation among the various units. Thus, for example, if the ship should keep her head toward the first torpedo-boat discovered, the effort of that boat should be to keep the attention of the ship directed toward itself, so as to allow its followers to launch, and afterward it might itself attempt to launch when the attention of the ship is perhaps attracted toward the others.

This torpedo-boat, if not destroyed, will finally find itself ahead of the ship and at a somewhat short distance, but it would never do to attempt to turn and run, since to turn through 90° would employ not less than 35 seconds, a time more than sufficient to allow the ship to run it down, while by steering to cut across the ship's circle of evolution, it will pass also at a short distance, but with the maximum relative speed, and there will remain for

it the hope of being able perhaps to launch a torpedo, although under bad conditions; which will always be better than having the certainty of running the same chance of destruction without attempting any launching at all.

Passing to consider the other extreme case, that is, when the attack is made on a course normal to that of the ship, we note that,

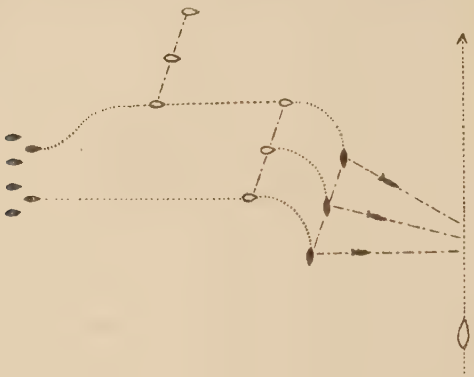


Fig. 6.

Fig. 7.

evidently, the attacks of the two sections that compose the squadron, if executed on the same side and in the same sector of the ship, must necessarily be successive, as is shown in Fig. 6; or it could be developed in different sectors as shown in Fig. 7.

From what I have said it seems to me that we may deduce the principle that, in order to obtain the best conditions, it would be necessary to attack by sections, and to assume formations de-

veloped ahead of the ship and along a line nearly normal to the line joining the ship and the group leader; understanding by *formation,* not a rigid formation, but a simple line of dispersion.

In the form of attack determined by such standards, the various units of the section would be almost in line abreast when the courses of approach are normal to that of the ship, while in the case of opposite parallel courses they would be almost in column of vessels, a little inclined toward the ship, and each torpedo-boat would keep the one immediately ahead a little on the bow.

In this manner, having the launching tubes trained at different angles, a series of successive simultaneous launchings could be executed, with angles of impact slightly different for the different units; the first series, for example, when the group leader is about

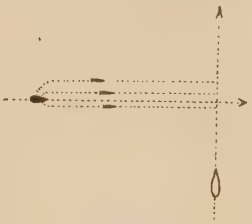


Fig 8.

1000 meters distant from the ship (launching distance=700 meters) and the others at shorter distances. And if the boats were provided with torpedoes having angle gyroscopes, each torpedo-boat, in the attack on a course normal to that of the ship, could execute three launchings at once from its three tubes, with which (see Fig. 8) it could constitute for the ship a danger zone about 100 meters in extent, and would not be obliged to change course [14] in order to launch, which would be a most important advantage.

The form of attack indicated would always leave clear water ahead of each torpedo-boat, would render it possible for all to see the target continually and would permit a good dispersion in order to diminish the probability of all being discovered at the same time and the probability of effective gun-fire; finally it would present the great advantage of being able to launch simultaneously or at minimum intervals.

[14] The torpdeo-boat in changing course through 90° must remain exposed to fire for 35 seconds more, during which the relative movement is minimum. (Author's note.)

It seems to me that the ideas set forth may represent how much of what is desirable might be accomplished under the best conditions, which does not exclude the fact that in practice we must deny ourselves some things, and often be content with what is possible, without thinking too much of what is desirable.

Therefore, the formations mentioned represent an ideal limit toward which we should tend; and this does not imply the necessity of always having a similar disposition also before the phase of the attack, although it is certainly logical in every phase of the maneuver to occupy oneself principally with the dispositions that may be best for the attack, which is the supreme object, rather than with those that may facilitate the previous maneuvers.

In the ideal attack, torpedo-boats, in hurling themselves against ships, should be so arranged as to approximate the nearest possible to the said formations, and, therefore, during the search they will be the better prepared for the attack the simpler and quicker the passage to the formation for attack can be made.

Hence it will be seen how important may also be a good initial disposition of the units of each section during the period of search, having in view good preparation for the attack; since, if facility of maneuvering in the phases preceding the attack is desirable, on the other hand, all those conditions that facilitate good dispositions for the attack are to be held as much more important.

Evidently, during the search, the various scouting groups will not traverse the sea at hazard, but will follow pre-established routes based upon the data of the problem, and such as to insure complete co-ordination of the partial scouting services of the single groups, and, therefore, the maximum probability of success.

In this phase, what is chiefly important is the assurance of reciprocal contact, the prompt transmission of news among the various units of the group, and the fact of not being found in relative positions too different with respect to the ship, in case it is discovered, and in respect to that position forward of the beam which it will always be necessary to gain. Being found in positions considerably less advanced with respect to the leader of the column, from which may spring the necessity of increasing the speed in order to close up, is very disadvantageous. Therefore, it seems to me that the order most suitable for this phase should not present facilities for excessive elongation, as in general is realized at night in the simple column of vessels.

The advisability of diminishing the length of the formation specially exists in the case of modern torpedo-boats with greater tonnage than those of the past.

All these considerations lead me to find in the lines abreast by sections, such as are shown in Fig. 9, the order that under certain conditions might lend itself sufficiently well to this phase, especially in view of the attainment of the ideal conditions for attack.

The triangular formation, in the case of a group composed of six units, is similar to the one advocated by Labrès, and to the one which according to Chandler is used in Germany.

FIG. 9.

Formations abreast are the ones that present greater safety in navigation at night with lights obscured, especially when, as is the case in every search, there are pre-established courses to be followed; they permit of the better exercise of vigilance in the sense of the direction followed; maintaining them is not more laborious than maintaining columns of vessels, nor is it as difficult as it may seem to those unaccustomed to their use. In columns of vessels, on the other hand, with high speed, it is easy to lose contact or vice versa, to have dangerous close approaches, especially in running with lights obscured, that is to say, when a distance of about a hundred meters suffices to cause one to lose sight of the stern of the boat immediately preceding, while in lines abreast or oblique it is much more difficult to lose sight of the dark lines of the entire length of the adjacent torpedo-boats. All recall what intense attention and what continual variations of speed the formations in columns of vessels require, which, therefore, soon bring about great fatigue.

In formations abreast the squadron is presented well subdivided into two tactical groups, ready to be separated for the opportune maneuvers.

Thus, for example, it is evident that in case of encountering the

ships on opposite courses, the arrangement abreast would lend itself very well to being so disposed as to attack from both sides (see Fig. 3). And it would lend itself equally well in the case of meeting with courses normal to that of the ship as is seen from Figs. 6 and 7. If the ship, even in this case, should maneuver so as to keep its bow toward one of the units sighted, there would result therefrom a situation similar to that already considered, and for which I have already pointed out the opportune counter maneuver. If instead it should change course with the helm hard

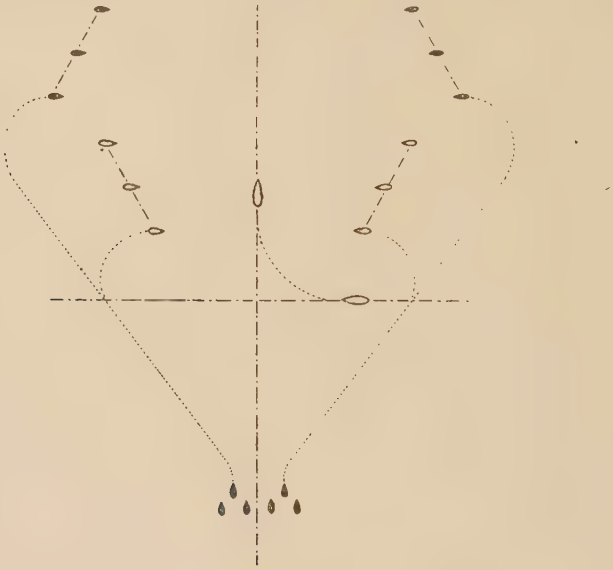


FIG. 10.

over, given the distance of sighting the boats, it might easily succeed in turning its stern in good time to the torpedo-boats, which in line abreast would be in an advantageous position for subdividing and spurting ahead in order to attack from both sides (see Fig. 10), or for maneuvering so as to try the attack from one side only.

I have principally considered the typical cases of attacks from positions included within the sectors forward of the ship's beam, in which the advantage of the lines of dispersion abreast for attack appears evident. I have scarcely mentioned attacks from positions abaft the ship's beam since, save in special cases they

must be held to be attacks of expediency, and for them there might be repeated considerations similar to those set forth.

It is not contended that the line abreast may not present inconveniences; but in this connection it must be remembered that while the passage from line abreast to column of vessels can be executed with great ease and without loss of time, certainly the same cannot be said of the contrary maneuver.

After all this, without stopping to make a minute analysis of all the possible cases of relative positions in meeting—which would be lengthy—it seems to me that, solely on the basis of what I have synthetically pointed out, it is possible to believe that, on the whole, the line abreast is the formation that can more easily conduce to the best conditions for attack, which, I repeat, does not exclude passing easily and without inconvenience from line to column.

I have said that the formations must not be understood as the means of arranging and conducting the various units before the attack, in order afterwards to hurl them against the enemy from determined positions; therefore, the various units in attacking, while not being kept strictly bound to the formation, but only by the principle of being spread out in scattered order sufficiently ahead of the ship, must keep well in mind that good success depends upon the maximum co-operation, and that, therefore, not only must they not interfere with each other, but they must also be able to discern how they may aid each other as much by seeking to keep the attention of the ship continually directed toward the same partial objective, as by seeking to keep themselves on the same line so as to arrive at the same time at the launching position, etc.

Naturally, attacks conducted according to similar standards would be regulated by special practical rules which I do not think it necessary to analyze, having proposed to limit myself to considerations of a general nature concerning the fundamental principles which determine the best conditions. My intention is more to bring out the object of the maneuver than the maneuver itself.

In practice the adoption of these criteria would perhaps, in its widest sense, signify the dispersion of the various units which had remained grouped together up to the moment of sighting the ship, with the maximum liberty of maneuver, and so as to hurl themselves against the enemy from different directions, seeking

to arrive at launching position at one and the same time, following only the indispensable rules in order to avoid interfering with each other when turning to withdraw; thus for example: no torpedo-boat must ever launch before the next nearer to or farther from the beam of the ship, according as the attack is developed in the bow or the stern sector profitable for launching.

It seems to me that these forms of attack may represent the rational theoretical solution which sufficiently reconciles all the varied and complex exigencies of the problem; forms that in certain cases might be practically realizable under conditions of darkness not excessive and against a squadron or a numerous convoy.

The results of numerous and accurate experiments, properly organized, might certainly prove to be much more interesting and convincing than all the considerations of a theoretical character that I have set forth.

In any event, however, whatever may be the judgment or the result of experience, the tendency to give so much value to certain too compact or excessively long orders of attack, which only permit successive launchings by the various units and at intervals not minimum, on the principle of sacrificing everything to the ideal angles of impact of 90°, seems to me illogical, and, above all, I do not understand the unwillingness sufficiently to recognize the value of the scattered order, and the taking into consideration only those forms that, while they may perhaps present possibilities of some advantages in the worst cases, certainly sacrifice the good conditions of those best cases that it must always be the intention to realize.

DISCUSSION.

The Stability of Smokeless Powder.

LIEUT.-COMMANDER RALPH EARLE.—Before taking up this article, I wish to preface it with a word to controvert statements made in a careful and apparently disinterested article on "Smokeless Powder" appearing in *Engineering* of October 21, 1910. This article severely criticized our powder, placing the blame for all the accidents which have happened to our ordnance to the multi-perforated grain of our powder.

Our experience with different forms of grains has been extensive, including the testing of many samples of powder made in various forms such as the solid rod which is claimed as *the* one proper type to use by this article; the strip or ribbon; single perforated cylindrical of various lengths; and multi-perforated of various lengths. The results certainly indicate the superiority of our present form. One 12/40 gun was ruined in these tests, and not by the present type of grain. No improvement in ballistic result due to the types of grain was indicated in any way. The theory of the burning, as frequently written, does not work out in actual practice, and results show that the form of the powder grain has far less to do with the ballistic result than is claimed. Indeed, for ballistic results our form of grain seems the logical one, for it allows more uniform charges, and charges that give less digression from the mean ballistic result, than those from any other form. Our grains, tested in many ways, have been proved not to break up in the guns, and to burn regularly under all pressures, even with a density of loading as high as seven-tenths. With the rod form this splitting into slivers with consequent erratic burning does occur often.

If our officers are dissatisfied with the present type of powder grain, as is stated, the fact has been well concealed. Even if "they" did agree that powder in form of slender rods in bundles are safer, it would be without consulting actual experience, but by unthinkingly using an overworked adage that because so and so is used by another service, it must, of course, be better than that used in our own service.

As to our powder not standing the heat test, both gun and powder have been heated to 212° F. and fired with pressures up to 20 tons, and with nothing resulting save the regular normal pressures and velocities. Our ships have cruised, and have fired their guns in the tropics continually, many trials have taken place in all degrees of temperatures with no disaster, but with marked success. There is certainly no ground for thinking that "one-half of the full charges fired" would result as predicted.

The following notes on the stability of our service powder are given as additional to the careful and accurate discussion of the subject by Commander Strauss. They are based mostly on the results of my own experi-

ence, particularly that in charge of Chemical Ordnance Laboratory, Philippine Islands working with Mr. George Rocker, chemist, and partly on the writings of various authorities. The plain way in which Commander Strauss has put the subject must tend to remove much of the distrust of our powder, chemically and ballistically, which exists in the minds of some officers. Experience with many stable and unstable powders in all climates has confirmed the opinion that, by intelligent compliance with the instructions laid down by the Bureau of Ordnance on the subject of the examination of powders in storage, an accident due to powder is most unlikely to occur in our service.

In addition to the accidents mentioned in the article, the three following are cited as being of interest to the service:

In February, 1898, the battleship *Maine* sank in Havana harbor from some unknown cause. As many items have appeared from time to time stating that this disaster was probably caused by the decomposition of our service smokeless powder, it is well to note that the *Maine* did not have smokeless powder on board at that time.

On April 30, 1908, the Japanese training ship, *Matsushima,* was sunk by an internal explosion at Bako, Pescadores. The board found the cause of the disaster to be the explosion of the magazine of the 12.6-inch gun, which magazine contained only *brown* powder, and that this was exploded by a fire in the magazine, not due to decomposition of any powder.

On September 11, 1905, an explosion sank the Japanese flagship *Mikasa.* The board in this case decided that the explosion was caused by the spontaneous decomposition of the tape-shaped 6-inch powder, cordite, stowed in the port after magazine.

It is, however, probable, from what could be learnt in the East, that a large part of the damage to the *Mikasa* was due to black powder stored in the vicinity of the smokeless.

These cases also show that the damage caused by smokeless powder is less than that due to brown or black powder.

The origin of the *Jéna* explosion was attributed by the commission of the French Senate to the decomposition of smokeless powder caused by the moist air of the magazines. M. Vielle still believes, it is reported, that the bilge pump bearings, the shaft of which passed through the center of the black powder magazine, were overheated, and caused the explosion, and that *no* evidence could be found to substantiate the spontaneous decomposition theory.

The fire, which occurred recently on board the powder hoy in New York harbor, cannot be definitely attributed to the decomposition of smokeless powder. Cases of this kind, where single charges or only very small portions of any particular index are in question, can almost invariably be traced to other causes than that of ignition by decomposition. Thus the case cited by Commander Strauss of the spontaneous ignition of a powder in a bottle placed in sunlight, can possibly be traced to the generation of an excessive heat inside the bottle. Professor Will cites a case where celluloid, inside of a paper bag, ignited with explosive violence when the bag was exposed to heat from a radiator, which heat was insufficient to ignite the celluloid when freely exposed to it.

Commander Strauss states that moisture is generally admitted to have a bad influence on the stability of powder. My experience in the Philippines leads me to emphasize this by stating that moisture is a far greater enemy of powder than the usual maximum temperature of shipboard storage. Practically all the powders which were found in an unstable condition on the Asiatic station showed an abnormal moisture content.

Moreover, contrary to the usual view, tropical temperatures play only a small secondary part in the deterioration of powder. The humid climate of the tropics, especially during the rainy seasons, is one of the chief causes of decomposition, unless the powder is carefully protected from moisture. Furthermore in air-tight containers changes of temperature accelerate the action of moisture; inasmuch, as during a rise in temperature, moisture volatilizes, which, during a subsequent drop in temperature, is reabsorbed by the powder and replaces the solvent. Several such changes of temperature may reduce materially the solvent content of the powder making it porous and more susceptible to decomposition.

Decomposition may be considered as taking place in two ways. First, by the action of heat, by which nitric oxide is liberated, which in turn is oxidized to nitrogen peroxide by the action of air, and is then reabsorbed by the powder, probably combining with the alcohol. Second, decomposition of the nitrocellulose into cellulose and nitric acid by the saponifying, or hydrolysing, action of the moisture. In this latter case the nitric acid would sooner or latter form decomposition products of the cellulose by oxidation. Such decomposition products, as oxalic acid, for example, no doubt play an important part in the rapid deterioration of powder. These chemical reactions liberate a certain amount of heat which may or may not be sufficient to cause ignition of the powder. At any rate it is doubtful that ignition will take place, unless the gaseous products are liberated at such a rate, that sufficient pressure is developed, either in a charge or grain to cause a very material rise in temperature. Major Eder, of the Austrian Army, states that an increase of 9° F. doubles the rate of decomposition of powder.

Commander Strauss leaves the impression that decomposing powder must ignite. Such is, I believe, the exception not the rule. The example given of a bottle placed in sunlight is not at all conclusive for by experiment, we have found that the sunlight gives inside of the bottle a very considerable rise in temperature. This, then, is materially aiding the heat of decomposition, and it is by no means unlikely that ignition would not have occurred without this added heat. A large number of instances are not only on record, but have come under my personal observation, where charges of powder in sealed containers have absolutely decomposed to inert masses without ignition or explosion.

Authorities agree that the addition of solvent to nitrocellulose adds to its stability, hence its replacement by moisture lowers its resistance. Since the work of Mr. Rocker showed that this replacement did take place, I have read, in this year's report of French progress that Vielle had also independently come to this same conclusion.

The chemical stability of nitrocellulose powders is, aside from the condition of raw materials and solvents, dependent to a large extent upon the

thoroughness of colloiding. The most stable type of powder thus far developed is one of high specific gravity with high percentage of solvent. The fewer the number of ingredients the better, hence the addition of oxidizing and preservative agents must generally be looked upon as a step backwards. Present experience, moreover, points to the conclusion that a further reduction of alcohol is not desirable. Improvements in our powders, both chemically and ballistically, must therefore be sought in the colloiding and granulating processes of manufacture.

For the preservation of powder on shipboard, dry air for magazine ventilation, and an equable moderate temperature are necessary. M. Vielle has stated that a diminution of the storage temperature, 18° F., will treble the life of the powder.

Referring to the usual stability tests:

The 135° C. test is less sensitive than the KI starch test, and was adopted as the only sure method of disqualifying powders containing so-called cellulose sulphates. The latter purpose it answers well, but, as an indicator of the real stability of powder, it is not of much value.

The KI starch test, and the 150° F. surveillance test have thus far demonstrated completely their worth as the most reliable of all service powder tests, and the last test, used in connection with every separate portion of powder as stowed on shipboard or on shore gives a reasonable indication for the retention in, or removal from, service of that portion of the index of powder. It is, of course, no indication if a part of an index stowed at the central laboratory, at Indian Head, for instance, is stable, that other portions of that index which have been stored under different conditions are stable, hence the necessity for frequent testing, such as is done by the Olongapo Chemical Laboratory.

It must be noted relative to the use of Saposchnikoff's curves, proposed by Commander Strauss, that they are curves of the decomposition of nitrocellulose and cannot be applied to smokeless powder. Moreover, they bring out the important point that, at the lower temperatures which Saposchnikoff used, nitrocellulose of the pyro type decomposes in a radically different manner than at high temperatures. The tests at high temperatures will not usually give results comparable to those given by normal temperatures. For instance, a test recently proposed to show effect of moisture on stability of powder was valueless because the temperature of test was 212° F., and moisture at that temperature attacks powder in an essentially different manner than it does as condensed moisture.

I have never read of an authentic instance where static electricity was at all responsible for the ignition of a *finished* powder. Commander Strauss here states that powder in storage will not liberate enough ether in storage to give an explosive mixture. The condition in a powder tank is probably the other case, that the maximum possible percentage where ignition is possible has been exceeded.

Powders decompose with various external signs, some with evolution of heat and thick nitrous fumes, others crumbling away to an inert sugary mass. Instances of both types of decomposition were noted in the Philippines.

According to the statement of M. Vielle, the use of amyl alcohol, re-

ferred to by Commander Strauss, as an addition to the solvent, actually renders a powder three to five times as stable as one in which ether alcohol alone is used.

The recent addition of a basic organic compound, diphenylamine, to our powder has been criticized on the ground that all such compounds mask the actual decomposition and prevent the stability tests from giving true indications of the condition of the powder. The most recently published work of M. Vielle has shown the importance of binding chemically the nitrous decomposition products, before they can react with the remainder of the nitrocellulose. This is the function of diphenylamine. The addition of diphenylamine, together with increase in the residual solvent, has, therefore, practically solved the question of the stability of our powders in storage.

In conclusion, I cannot quite agree with the proposition that we cannot prophesy the future probable stable life of powder. That life depends on the storage conditions, and by following these we are able to tell, in a large degree, what will happen to different portions of the same index.

HUDSON MAXIM.—I have read, with intense interest, the able article by Commander Strauss on "The Stability of Smokeless Powder."

I believe that the experience of the last half century, derived from the manufacture, storage and use of pyroxylin in its various forms and grades, justifies the conclusion that, quite irrespective of the care taken in its purification during manufacture, it begins, though slowly, to decompose spontaneously the moment it leaves the mill a completed product, and it continues decomposing with increasing rapidity until entirely disintegrated.

Nitrocellulose belongs to that class of chemical compounds in which the products of incipient decomposition tend rapidly to accelerate further decomposition. Since the discovery of radiant matter, we have learned that chemical stability is very largely a condition of instability. From some yet unexplained cause, the nitrocellulose molecule tends to unravel. This unraveling or breaking-down varies widely with different grades of the material. But in a dry state, complete decomposition is only a matter of time. Nitrocellulose in the form of the dense colloidal powder grain now in use, from purely physical reasons naturally decomposes more slowly than the nitrocellulose in its original fibrous condition. Still, although its decomposition proceeds more slowly, it nevertheless goes on.

Experience seems to show that a neutral diluent compound with nitrocellulose tends to retard decomposition. For example, celluloid pyroxylin is one of the most unstable of all the varieties of nitrocellulose, but the thirty to forty per cent camphor combined with it to form celluloid, acts as a stabillizing agent and greatly retards decomposition. It is better that a diluent should be also a solvent of the nitrocellulose, as camphor is of that particular grade of nitrocellulose employed in the manufacture of celluloid.

Stabillite consisting of a compound of tri-nitroanisol and nitrocellulose, for example in the proportions of forty per cent tri-nitroanisol to sixty per cent nitrocellulose, makes a remarkably stable smokeless powder compound, as has been proven by keeping samples of the material for long

periods of time under very unfavorable conditions. The presence of the tri-nitroanisol by diluting the nitrocellulose serves as a preservative of it.

Compounds of nitroglycerin and nitrocellulose, such as cordite and ballistite, are well known to be quite satisfactory in respect of mere stability.

It is well known that when fibrous guncotton is kept wet, it is preserved much better than when kept in a dry state. The water, although not a solvent of the pyroxylin, still, to some extent, serves the purpose of a diluent, retarding decomposition, while it, at the same time, instantly dilutes and absorbs any products of decomposition.

A diluent which is also a solvent of nitrocellulose possibly owes much of its preservative power to its absorption and dilution of the products of decomposition in the same manner, but it doubtless serves the additional purpose of separating the molecules of the nitrocellulose, and thereby shielding the sound molecules by quarantining them, so to speak, from the diseased molecules.

G. W. PATTERSON.—In smokeless powder indices which in service have developed instability, it nearly always happens that part of the lot becomes very bad, while the balance in storage at magazines or in use on other ships is in good condition.

Alcohol as an ingredient of powder is without question a preservative for the nitrocellulose, and the quantity of alcohol present, to a considerable degree, determines the life of the powder, so that anything which tends to reduce the quantity of this ingredient hastens instability.

Powder exposed to the air is subject to two conditions. The alcohol evaporates at ordinary temperatures and, as it evaporates, the powder becomes porous. Powder also absorbs moisture and the moisture content depends on the temperature and humidity of the atmosphere to which it is exposed. Evaporation and absorption of moisture from and by the powder grain have a double effect. The moisture leaving the powder carries with it alcohol in excess of what would naturally evaporate. The second effect produced is the well known hydrolytic action of moisture on nitrocellulose setting free the oxides of nitrogen, in exactly the same way that they are set free when the powder is heated. The rapidity of such action depends on the temperature.

The keeping qualities of the powder depend on proper assembling and handling in service, as much as upon the quality of the material itself, and there can be no expectation of stability if the powder is shipped in leaky boxes, or put up in tanks which are not tight or in rounds with loose shell, and the necessity for proper handling aboard ship is apparent.

While changes in volatile contents of powder have an exceedingly bad effect chemically, it must not be supposed that the ballistics of such powders are necessarily altered. The charge for a lot of powder is fixed with a known content of alcohol and moisture, the sum of the two being known as "total volatiles." It has been proven that, provided the percentage of total volatiles is not changed, their relative proportions may differ widely, *i. e.*, a powder with 3 per cent alcohol and 1.5 per cent moisture gives the same ballistic results as the same powder with 4 per cent alcohol and 0.5 per cent moisture.

PROFESSOR PHILIP R. ALGER, U. S. N.—The numerous instances, some of which are cited by Commander Strauss, where smokeless powder charges have been ignited, either spontaneously or by some accidental extraneous cause, and have burned up in ship's magazines, without causing any serious damage and even without setting fire to the rest of the powder in the magazine, should serve to reassure anyone who fears a repetition of such disasters as the blowing up of the *Maine* and the *Jéna*. It is well to emphasize the fact that, in both those instances, it was the explosion of large quantities of black gunpowder that wrecked the ships. Putting entirely aside the question as to what originated the explosions, it was not the brown powder in the *Maine's* magazine that destroyed her, but the 3400 pounds of black saluting powder in the same magazine, and it was not the smokeless powder in the *Jéna's* magazine that destroyed her, but the black powder in an adjoining and communicating magazine. The lesson has been learned and we no longer carry gunpowder in or near magazines containing smokeless powder, so that such a thing as the blowing up of a ship from fire in a magazine need not be feared. A further step that would greatly reduce the danger of serious damage in the remote contingency of a powder charge becoming ignited would be to remove all inflammable material except the powder itself from magazines. The wooden boxes in which fixed ammunition is stored, and particularly those containing the 5-inch and 6-inch brass cartridge cases, greatly increase the probability of a fire spreading from one charge to others. This consideration, besides such others as reduced weight, space and cost, seem to me to clearly indicate the superiority of the powder bag to the brass case for all guns in which separate loading is used.

As for the possibility of spontaneous ignition, we know that heat and moisture are the two deadly agents of decomposition whose joint attack is always fatal. If the powder can be kept cool and dry, its stability is all that can be desired.

LIEUT.-COMMANDER R. W. MCNEELY.—The author's conclusions demand careful study by all who are concerned with the care and use of smokeless powders afloat and ashore; they are stated in clear terms and voice practical and advanced ideas on this subject. The attention of all is called to the following points brought out by the author:

(a) The probability of fighting successfully a fire in the ship's magazine due to the ignition of a charge through any cause, where the heat due to the burning charge is not augmented by the ignition and burning of other inflammable materials (outside other charges) in the magazine.

(b) The probability of discovering powder of lowered stability before the danger limit of spontaneous combustion is reached by means of the routine examinations and tests required by service regulations.

A recital of the main circumstances connected with the burning of a section contained in an 8-inch powder tank referred to at New York will show that smokeless powder lightly confined, as it is in powder tanks, will not explode with violence when heat communicated through the metal sides of the containers raises it to the ignition point, but will burn as a highly inflammable fuel.

An ammunition lighter fitted with a wooden deck and a wooden deck house was receiving 8-inch powder tanks from an auxiliary, over two hundred tanks had been placed on the lighter when the powder in a tank, which was being handled by a man, ignited, blowing off the top of the tank and scattering burning grains over the deck of the lighter. The man who was handling the tank was barefooted and his feet were slightly burned by the ignited grains of powder. This was the only injury to personnel directly due to the explosion of this tank. The wood-work caught fire immediately and this heat communicating later to the powder tanks already on the lighter caused them in succession to blow off their covers with a low explosion or to open up the seams in the tanks, the powder, of course, burning up. If ready means of fighting the fire, such as the flooding and sprinkling arrangements of a ship's magazine, had been at hand, it is probable that the fire, even with the unfavorable design of the lighter, could have been confined to the one burning powder charge, and it appears to be certain that, if the lighter had been fitted with non-inflammable decks, deck house, and other fittings, the charge would have burnt itself out without any other untoward result.

The immediate lesson to be learned from this incident is the great influence inflammable materials near ignited smokeless powder exerts upon the ultimate effect of an initial explosion. It appears to me that no effort ought to be spared to reduce to the lowest limit the wood-work, wooden ammunition boxes, and other highly inflammable materials usually to be found in ships' magazines.

The opinions of experts in regard to the spontaneous ignition of powder of normal physical appearance at ordinary temperatures seem to be at such variance that, at present, without definite proof, it is my opinion that well-made nitro-cellulose powder unexposed to the rays of the sun will not ignite spontaneously before its dangerous condition has made itself apparent by its altered physical appearance, and by a distinct lowering of the KI and surveillance tests; that is, the limits which have been set on the KI, surveillance, and other tests for withdrawal from service afloat give us a very great factor of safety. The very bad influence that moisture alone, and worse when combined with heat, has on powder should be impressed upon all; the tendency of the solvent to be replaced by moisture from the air is great and this can be prevented by having efficient air-tight containers.

The delicacy and speed of the KI test is its greatest advantage and it has stood the test of long service; a great fault of this test lies in the small percentage of a grain tested. The surveillance test is hard y enough for a service test and it has the great advantage of testing several whole grains at once; its fault lies in the length of time to finish the test, although a bad powder shows early—and one can afford to wait on a good powder.

The relation between the KI and surveillance tests in the early stages of nitro-cellulose decomposition is a question of the greatest moment and the records of the service tests, to be carried in parallel for several years, undoubtedly will go a long way in solving this problem.

PROFESSIONAL NOTES.

Prepared by Professor PHILIP R. ALGER, U. S. Navy.

SHIPS OF WAR, BUDGETS AND PERSONNEL.

ARGENTINE REPUBLIC.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Rivadavia	28,000	Fore River Shipbl'dg Co.	Building.
Moreno	28,000	New York "	"

Messrs. Yarrow & Co., of Glasgow, have received an order for a high-speed motor-boat for service at Buenos Aires. The vessel will be 60 feet long by 9 feet beam; propelled by five sets of internal combustion engines of the Yarrow-Napier design, of approximately 300 total horse-power, designed to give her a speed of 25½ knots. She will be practically similar to the *Mercury II,* built by Messrs. Yarrow for the British Admiralty.

AUSTRIA.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Radetsky	14,500	Trieste.	Launched July 3, 1909.
Zrinyi	14,500	"	" April 12, 1910.
Erzherzog Franz Ferdinand.	14,500	"	Under trial.
Tegetthoff	20,000	"	Building.
Kaiser Franz Joseph	20,000	"	"

At last Austria-Hungary is showing her hand, and it looks as though the Navy Department would after all obtain authority to carry out the programme of construction of which so much has been heard. Admiral Count Montecuccoli, Chief of the Navy Department, has made an important statement in justification of the progress which has been made on two Dreadnought ships before the authority of the Delegations was given for any expenditure. In July, 1909, two slips had become vacant in the yard of the Stabilimento Tecnico at Trieste, and the Stabilimento applied for orders which the admiral could not give, although battleships were urgently needed. Recognizing this difficulty, and in order to avoid a partial suspension of work and the discharge of hands, the Stabilimento offered to build on its own account two battleships according to plans to be sanctioned by the Naval Department. In view of the feverish activity in the naval arsenals of the great powers, and even of Spain and Turkey, it was impossible, the minister claimed, for Austria-Hungary to lag behind without losing for years to come all right to count as a naval power. In the circumstances the offer of the Trieste yard was accepted, but the minister gave assurances that neither the price agreed upon nor any instalment thereof had been paid by the Austrian or the Hungarian Governments. The main fact which emerges from the discussion of the navy estimates this week is that the Austrian authorities have forced

the hands of the Delegations and committed the country to a very large expenditure on naval construction.

Undertakings having been given to the Trieste shipbuilders the government is apparently looking around to see how the necessary money can be obtained. So far European financiers have not shown any undue anxiety to provide the Austro-Hungarian Government with funds, and everything points to the payment for the new shipbuilding programme being spread over a large number of years. There is, however, another way out of the difficulty, and this was hinted at in significant language by the Chief of the Navy, who observed that "in view of the very active demand for such vessels, the Stabilimento Tecnico would, doubtless, be able to sell these battleships immediately to someone else." This is not the first time that the purchase of the two Austrian-built Dreadnoughts by "some one else" has been mentioned.—*Naval and Military Record.*

The new Austrian scout, *Admiral Spaun,* made a speed of 27.07 knots, being 1.07 knots over the contract speed. The *Admiral Spaun* is the first ship in the Austro-Hungarian Navy to be fitted with turbines.—*The Engineer.*

BRAZIL.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Rio de Janeiro	19,250	Elswick.	Building.
São Paulo.	19,250	Vickers.	Under trial.
Rio de Janeiro.....	32.000	Elswick.	Ordered.
Scouts.			
Bahia	3,500	Elswick.	Under trial.

TORPEDO-BOAT DESTROYERS.—Messrs. Yarrow & Co. have successfully completed ten torpedo-boat destroyers for the Brazilian Government.

These destroyers are all of one design, which, of itself, is an important advantage, not only from the tactical point of view, but also from the standpoint of management by Brazilian officers and crews. They partake generally of the characteristics of the British *River* class, in which there were embodied greater strength and other qualities to enable the vessels to maintain their speed in a heavy sea. Thus, high forecastles were fitted and the scantlings generally increased, the consequence being that while in the earlier British destroyers a speed of 30 knots was realized, the rate for the *River* class was reduced to 25½ knots. In the destroyers built by Messrs. Yarrow for the Brazilian Government, however, such modifications were made as to ensure, in combination with ample strength of construction, a guaranteed speed of 27 knots, and in every ship this speed has easily been exceeded.

The length between perpendiculars is 240 feet, the beam 23 feet 6 inches, the depth 14 feet, and the draft 7 feet 6 inches when the displacement is 650 tons. The ratio of length to beam is 10.2 to 1. The vessels are notable for several features, prominent among them being the adequacy of the living quarters, the application of refrigerating installation for the purpose of cooling the magazines, and the circulation of cold air in the ward-room, cabins and other parts. Each of the vessels carries a large motor-pinnace. The Marconi wireless apparatus has been installed, the aerial lines passing from the mast to a special jigger aft. High-tensile steel is used in the parts of the hulls where longitudinal strength is important, and the rivets used are of the same strength per square inch as the plates they connect. The ships are divided into ten water-tight compartments by bulkheads from the outer bottom plating to the upper deck.

The vessels are fitted with two sets of four-cylinder triple-expansion engines, balanced on the Yarrow-Schlick-Tweedy system, supplied with

steam from two double-ended Yarrow boilers. The firing of these boilers from both ends is a unique feature, and we gave drawings of the boilers in connection with our previous article. The total grate area is 267.5 square feet, and the heating surface 14,980 square feet, the ratio of heating surface to grate area being 56 to 1. The highest power developed on an official trial was 8877 indicated horse-power in the case of the *Parana*. This gives 33.1 horse-power per square foot of grate area, while the heating surface on this occasion was equal to 1.69 square feet per unit of power. This power was realized with an air-pressure in the stokehold of 2.43 inches. In the case of the *Sergipe* almost as high a power was reached—8554 indicated horse-power, with an air-pressure of only 1.66 inches, while in the *Alagôas* 7400 horse-power was obtained with only 1½ inches of air-pressure. These results clearly show that the boilers were thoroughly adequate for their work, and gave a high rate of evaporation. In service this double-ended type of boiler has given complete satisfaction, and it promises to be extensively adopted. Among the advantages resulting from the system is the reduction by one-half of the steam and feed-pipes, and of the steam-pumps; and there is thus great gain in all warships, and especially in torpedo-craft, where space, particularly in the machinery compartment, is unavoidably limited.

Results of Official Three Hours' Full-Power Trials.

Name of Boat.	Speed. knots.	Revolutions.	I. H.-P.	Air-Pressure in Stokehold. inches.
Para	27.259	333.04	7014	1.22
Piauhy	27.211	330.7	6563	1.53
Amazonas	27.178	336.72	6898	1.64
Matto Grosso	27.160	338.11	7403	1.63
Rio Grande do Norte	27.275	341.7	7778	1.9
Parahyba	27.290	335.44	6700	1.26
Alagôas	27.253	337.7	7403	1.51
Santa Catharina	27.305	337.5	6982	1.55
Parana	28.736	354.4	8877	2.43
Sergipe	27.605	364.5	8554	1.66

Equally favorable results were got on the maneuvring trials. The diameter of the turning circle at full speed was about 375 yards, and at two-thirds speed about 330 yards. In the stopping and starting trials the boats began to move astern from full speed ahead in 30 seconds from the time the signal was given by the telegraph, while they began to move ahead from full speed astern in 25 seconds from the time of moving the telegraph. The coal-consumption trials showed that at 14 knots speed the radius of action was 3690 nautical miles; the bunker capacity is 140 tons.—*Engineering.*

GUNNERY INSTRUCTORS INVITED.—It is officially announced that there are vacancies in the Brazilian Navy for 10 gunnery instructors, for which pensioned chief petty officers and first-class petty officers are eligible. The pay will be £18 per month, including cost of uniform; and the rank will be that of first sergeant, which is the highest rank in the Brazilian Navy below commissioned rank. The period of engagement will be for 2 years, during which they will be required to wear Brazilian uniforms and to be under Brazilian laws; and if the engagement is prematurely terminated on the initiative of the Brazilian Government, not due to misconduct on the part of the men concerned, 1 month's pay will be given in addition to passage to England. Those serving in Brazilian ships must make their own arrangements as regards their wives and families, and those in shore establishments will be given married quarters if necessary.—*Naval and Military Record.*

CHILI.

Inquiries have been sent out for tenders for the new battleships for the Chilian Government. The ships are to be about 24,000 tons displacement, 600 feet long and 89 feet beam, and are to steam at least 23 knots. The armament will consist of ten 12-inch 50-caliber guns, supplemented by twenty 4.7-inch quick-firing weapons. There will also be four 21-inch torpedo-tubes. Wide scope is given to the builders in the matter of alternative designs embodying a considerably heavier armament. The arrangements of turrets is virtually the same as in the *Neptune* class of the Royal Navy.

FRANCE.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Danton	18,350	Brest.	Launched July 4, 1909.
Mirabeau	18,350	Lorient.	" Oct. 28, 1909.
Voltaire	18,350	Bordeaux.	Under trial.
Diderot	18,350	St. Nazaire.	Launched Apr. 19, 1909.
Condorcet	18,350	"	Under trial.
Vergniaud	18,350	La Seyne.	Launched Apr. 12, 1910.
Courbet	23,500	Lorient.	Building.
Jean Bart	23,500	Brest	"
Armored Cruisers.			
Waldeck-Rousseau	13,644	Lorient.	Launched Mar. 4, 1908.

THE NAVAL PROGRAMME.—It appears from the *Moniteur de la Flotte* that some doubt attends the French naval programme. When will it be discussed? What will be the periods for laying down the ships if the law cannot be discussed before the budget? What will be the characteristics of the new ships? The Minister of Marine finds himself in a difficulty in proposing to build ships armed with 12-inch guns, when ships of other nations will have guns still more powerful. No change will be made in the *Jean Bart* and *Courbet,* for which the guns are now in hand, and the possible need of installing guns of larger caliber in their successors may lead to some delay. The *Yacht* thinks that the programme, after the favorable reports passed upon it, and the speech of the President of the Council on board the *Saint Louis,* will be sanctioned. It should be discussed as soon as possible, because two battleships are to be laid in 1911, and it would be unsatisfactory if another such special arrangement had to be made as was necessary in the case of the *Jean Bart* and *Courbet.* The *Yacht* would like to reduce expenditure on these ships in order that four battleships may be laid down next year instead of two.—*Army and Navy Gazette.*

SUBMARINES AND SUBMERSIBLES.—In a recent Bulletin of *La Société des Ingénieurs Civils de France,* Monsieur Laubeuf, whose name is so well known in connection with submarine vessels, discusses the present position of the construction of submarines and submersibles—particular regard being had to the place held by France as compared with other nations.

M. Laubeuf points out that in 1902 France was in an absolutely exceptional position as regarded submarine navigation. She possessed 14 submarines and submersibles actually completed, while she had 23 submarines and 13 submersibles under construction—the total representing 50 vessels. England had five submarines completed and one under construction; the United States had six finished and two in an uncompleted state; Italy had one, and all the other powers—Germany, Austria, Russia—had not got one. France, therefore, had a good start in the race—such a good start, in fact, that it seemed certain she would hold the foremost place

for very many years. Unfortunately, he adds, matters have not thus turned out. The lead held by France has diminished rapidly.

This diminution is, he explains, due to several causes. The first of these is the considerable effort which has been put forward by other nations to reduce the difference. Since 1902 England has each year regularly laid down 12 submarines, and each has on an average taken 2 years to complete. She possessed—when Monsieur Laubeuf's article was written—77 submarines, of which 60 were actually afloat. At the same time France had 79 in hand, of which 55 were afloat. Thus it is England and not France who holds the lead at the present time.

Meanwhile Germany has been forging ahead. The budgets of that country comprised for submarines £250,000 in 1907, £350,000 in 1908, £500,000 in 1909, £750,000 in 1910, and for the years to come in a similar proportion. Russia possesses 31 submarines and submersibles, all of them afloat, but has not laid down any more for some 3 years now. The United States have already 28 submarines, and are continually adding to their flotilla. Italy has 7 and is proposing to construct 12 others. Austria also has 7.

Has France, asks Monsieur Laubeuf, been doing all she could to keep her lead? The answer, he says must be in the negative. In 1902, for example, when Monsieur Pelletan went to the Ministry of Marine, the building of 11 submersibles which were then on the stocks was suspended, and this stagnation continued during the 3 years of the Ministry.

Monsieur Laubeuf has still another fault to find. The construction of submarines is confined entirely to the arsenals, which, having nothing to stimulate them to activity, have worked on the boats in a desultory manner, and have reached figures which are absolutely pitiable as regards length of time taken in building. For example, in October, 1903, the building of six submarines of the *Emeraude* type was ordered: in February last there were still three of this batch which had not finished their trials! In October, 1904, some submersibles of the *Circe* type were ordered. They were finished in the middle of 1909, having taken 5 years to build. In 1905 18 submersibles of the *Pluviôse* type were ordered. Of these eight or nine are finished, and it is hoped that six more may be completed during this year. The three others will not be finished till next year, when they will have been 6 years under way, while the average for the 18 is 5 years. In 1906 16 other vessels of the same type slightly modified were put on order. They will not all be finished till 1912.

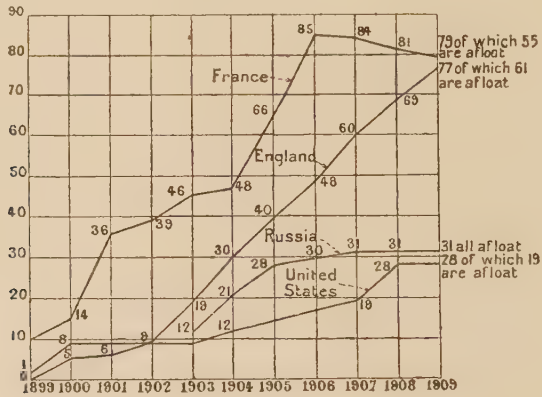
Then, again, continues Monsieur Laubeuf—a more extraordinary thing still! In 1907, 1908 and 1909 Parliament voted sums for the laying down and building of 10 submersibles in 1907, of 6 in 1908, and of 5 in 1909. Now, when Vice-Admiral Boué de Lapeyrère went to the Ministry of Marine it was found that not one of these 21 vessels had been even begun. They were therefore entirely struck out of the building programme.

This state of things, says Monsieur Laubeuf, cannot go on. "Why are we," he asks, "in such a humiliating position? Why have not the boats been built in private yards? They could build them in 2 years instead of taking 5 or 6 over them. It is thus that our lead has been lost!" Who is it, he demands, who is opposed to the boats being constructed by industrial firms? It is the Ministry of Marine itself which has hitherto entrenched itself behind this formula: "The construction of submarines is a secret of national defence." What, he demands, has been the opinion of former Ministers, men worthy of attention not merely for their high position, but by reason of their personal valor?

Commandant Gougeard, Minister of Marine in the Gambetta Cabinet, said: "The policy of secrecy and silence has succeeded too badly hitherto for us to say that the moment has not arrived for us to try another plan." Monsieur de Freycinet, giving evidence at Rennes, when questioned regarding the secrets of national defence, said: "There are two cases in which secrecy is useful, (1) in periods of change of armament, if the

new engine or arm remains unknown during the time it is being manufactured, that would give us a lead of 6 months or a year as compared with other nations; but when the arm or engine is in service its divulgence becomes inevitable; (2) as regards the names of our agents abroad."

Monsieur Laubeuf's comment on this is that it is good sense. The French submarine vessels are no more unknown to foreign nations than are those of these nations to the French. "We know," he says, "how the German, Italian, English and American boats plunge; it is quite certain that foreigners know how our boats do it. . . ." Take, for another example, he remarks, the periscope. "In France we have an excellent apparatus. The English have that of Grubb; the Italians that of *La Societé Galileo;* the Germans that of Goertz. Each nation thinks its own the best, which leads to the supposition that all of them are more or less equally efficient. When the world is faced with a problem, this problem is solved everywhere in a manner which, if not actually identical, is very near to being so."


France
England
Russia
United States
79 of which 55 are afloat
77 of which 61 are afloat
31 all afloat
28 of which 19 are afloat
1899 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909

The conclusion that Monsieur Laubeuf draws from the foregoing is that there is no reason whatever why submarines should not be built in private yards. Such a course would not only be without inconveniences, but it would, on the contrary, entail absolute advantages. The first of these is that construction would be more rapid. It would also engender a spirit of rivalry between the private yards and the arsenals—or dockyards, as we call them—and thus give an impetus all round, but it would enable the State to impose penalties if the boats offered for delivery were not up to specification. At present if a boat is below its speed there is no redress, saving to throw it on the scrap-heap—as has been actually done—or to remodel it entirely.—*The Engineer.*

The submarine *Archimede* has just accomplished a voyage of 1400 miles in less than 5 days, indicating her capacity to accompany a fleet away from home waters. Up till now the longest voyage of a submarine was that of the American *Salmon,* which covered the 750 miles between Quincy, Mass., and the Bermudas. The *Archimede's* record was performed at the average rate of 12 knots, or 280 miles day. It is now intended to send the *Archimede* from Cherbourg to Toulon and Bizerta, a distance of about 2500 miles.—*The Engineer.*

AVIATION IN THE NAVY.—Some particulars have already been given here of the energetic work that is now in progress in the French Navy in the matter of aviation and aerial navigation. A regular branch is to be cre-

ated, and seven lieutenants and sub-lieutenants had recently undergone, or were about to undergo, the examination in the pilotage of aeroplanes. Admiral Le Pord is presiding over a committee at the Ministry of Marine, of which the object is to prepare a programme of construction, the execution of which it is intended to give out to tender. As has already been explained, the three centers will be Cherbourg, Brest, Toulon and Bizerta. It is intended to make the new service in the first place a powerful help in coast and port defence. Aeroplanes will be able to keep the admiral in his port aware of the neighborhood of any enemy, and they will be of service in discovering the location of mines. There seems to be an idea that they might take flight from some kind of pontoon placed beneath them. It is admitted that there is no definite knowledge of how they can be employed on board ship, unless it should be possible to hoist them out and in like steamboats, and perhaps in this work some kind of pontoon might be useful. A good deal of this is, of course, speculative, but we find such ideas expressed in the French naval papers. It is now well understood in France that aviation should find very apt pupils in naval officers, and that the naval service is likely to gain much from the new means of observation.—*Army and Navy Gazette.*

La Vie Maritime, in a lengthy editorial, ridicules the idea of the naval use of aeroplanes, calling it a new folly that threatens the French Navy just when it has escaped from its past follies, the torpedo-boat and submarine.

The Minister of Marine has revoked a regulation dating from 1887, which forbade naval officers publishing anything whatever without having first obtained permission from the Navy Department. Officers henceforth may publish whatever they will, provided it is over their own signatures (with rank and title), the Department, of course, holding each one responsible for what he publishes.

The centennial of the French Naval Academy has passed without commemoration. A century has elapsed since, on September 16, 1810, Napoleon I decreed the creation of the *Ecole navale.* At first it comprised two sections, one at Brest, the other at Toulon. Each of these sections had 300 pupils, who paid 800 francs a year apiece. To enter it was necessary to be over 13 and less than 15 years old, and to know how "to write clearly and correctly; to be acquainted with the first four rules of arithmetic, fractions, decimal calculations, squares and cubes as far as series." The course lasted 3 years; the students lived on shipboard, on the *Tourville* at Brest, and on the *Duquesne* at Toulon. Each of these schools was commanded by a captain, with a commander, four lieutenants and four ensigns as assistants.—*La Vie Maritime.*

GERMANY.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Ost Friesland.....	19,000	Wilhelmshaven.	Launched Sept. 30, 1909.
Thüringen.....	19,000	Bremen (Weser Yard).	" Nov. 27, 1909.
Helgoland.....	19,000	Kiel (Howaldt).	" Sept. 26, 1909.
Oldenburg.....	19,000	Danzig (Schichau).	" June 30, 1910.
Ersatz Hildebrand ...	20,000	Kiel (Kaiserliche W.).	Building.
" Heimdall.....	20,000	Hamburg (Vulkan).	"
" Hagen..... ...	20,000	Kiel (Howaldt).	"
" Aegir.....	20,000	Danzig (Schichau).	"
" Odin.....	21,000?	Wilhelmshaven.	"

Armored Cruisers.			
Moltke	21,500?	Hamburg (Blohm and Voss).	Launched April 7, 1910.
H	21,500?	Do.	Building
J	21,500?	Do.	"
Protected Cruisers.			
Kolberg	4,300	Danzig.	Under trial.
Koeln	4,350	Kiel.	" "
Augsburg	4,350	"	" "
Ersatz Bussard	4,500 ?	Stettin (Vulkan).	Building.
" Falke	4,500 ?	Bremen (Weser).	"
" Cormoran	4,500 ?	Bremen (Weser).	Ordered.
" Condor	4,500 ?	Wilhelmshaven.	"

The naval programme will consist of three battleships, the *Ersatz Brandenburg*, the *Ersatz Wörth* and *"S"*; also an armored cruiser *"K."*

Having at last passed through the official naval acceptance trials, the third and fourth Dreadnoughts *Posen* and *Rheinland* have been commissioned at Wilhelmshaven, which is now their headquarters. As experience is gained with this quartette, it becomes even less popular than before, owing to the crowded nature of the crew and officers' accommodations, as well as to the congestion on the main deck, which materially hampers the manipulation of the 6-inch guns.

The comparative trials of the *Nassau* class have given the following results: *Rheinland*, 20.01; *Nassau*, 20.03; *Westfalen*, 20.03, and *Posen*, 20.05.

The funnels of the *Helgoland, Thuringen, Ostfriedland* and *Oldenburg*, the second batch of Dreadnoughts, are somewhat peculiar, being all of the same height, but of varying fore and aft lengths; the forward funnel is the widest, seen broadside on, and the after one is the narrowest. They all spring from the pyramidal style of base that has been adopted in the more recent vessels of the navy, and which forms the air-inlets casing for the stokeholds.

The Berlin *Tageblatt* learns that the naval estimates for 1911 provide, for the first time, for an effective strength of 60,000 men, as compared with 57,170 in the estimates for 1910. This increase is due to the addition of Dreadnoughts and armored cruisers to the fleet, which require stronger crews than they replace, and to the extension of the torpedo-boat flotillas, the formation of the new naval artillery division, which is quartered in Heligoland, and the requirements of the new submarines. The maintenance of a sixth torpedo flotilla during the coming winter is also contemplated.

Very extensive experimental trials were recently carried out in the Baltic by the ordnance authorities on the old battleship *Deutschland*. The appearance of the vessel, as she lies at present, is strikingly similar to that of the *Duke of Edinburgh*, which was fired at by the British gunnery experts, and which still remains in Portsmouth dockyard, partially screened in canvas, to remind one of the devastating effect of bursting shell. The upper works, bridge, funnels, mast and unprotected sides of both ships are absolutely riddled with holes to an almost unbelievable extent.—*The Engineer.*

ZOELLY TURBINES IN THE NAVY.—We are informed that, in consequence of the excellent results obtained in destroyers fitted with the Zoelly marine turbine, the German naval authorities have ordered from the Germania Yard, Kiel, six more boats thus equipped. Official data as to the trials

have not been published, but the figures given in the following report, translated from the *Zeitschrift des Vereines Deutscher Ingenieure* for March 26 last, are understood to be authentic. The torpedo-boat *G 173*, built by Messrs. Krupp & Co., of Germaniawerft Kiel, carried out her trials on the measured mile in Eckenford Bay. This boat has a displacement of 650 tons, and is propelled by Zoelly turbines, designed by Messrs. Escher Wyss & Co., the total power being 16,000 horse-power. On trial, in about 25 meters of water, and in a slight wind, this boat reached a speed of 33.35 knots, the shaft power at this speed being 8200 horse-power in each shaft at about 690 revolutions. *G 173* is the first German warship fitted with Zoelly turbines.—*Engineering.*

THE SALE OF WARSHIPS.—The sale by Germany of the two battleships *Weissenburg* and *Kurfürst Friedrich Wilhelm*, 9874 tons, to the Ottoman Government is an event which may have considerable significance. The price to be paid is about £900,000, but it is not known whether the ships are to be taken over and reconstructed by Turkey or whether some re-armament and improvement of the ships is included in the contract. It seems to be believed by the Socialist organs in Germany that the sale of the ships may make it possible to add other vessels to the German programme, but this is not assured. The shrinkage of the German programme of construction of capital ships will not begin under the navy law until 1912, when two should be laid down instead of four. The two ships which are being sold belong to the *Brandenburg* class, and two ships will be laid down in 1911, according to the programme, to replace two ships of the class, as well as an additional battleship and a cruiser-battleship. It is in 1912 that the pinch will begin to be felt in the building yards, so that it is, on the whole, improbable that any addition will be made to the actual programme of 1911, whatever legal provision may be made for its successor. There is another reason why it is not desired at present to make additional demands for the navy, in the fact that greater outlay is required for the expansion of the army under the new Quinquennial Law, and the accession of £900,000 to the naval exchequer will to some extent relieve the situation. The ships which Turkey acquires were built respectively at Wilhelmshaven and the Vulcan Yard, Stettin, being launched in 1891 and completed in 1893. They have a main armament of six 11-inch guns in three barbettes.—*Army and Navy Gazette.*

The second modern division of the Wilhelmshaven squadron will not be made up till the spring of 1912, since the *Oldenburg*, the last of the *Helgoland* class, was only launched last June and will not have her acceptance trials till April, 1912. The four *Helgolands* carry eight 12-inch guns each, and are of between 19,000 and 20,000 tons displacement; they will be the last battleships fitted with reciprocating engines. It is reported that battleships after the *Erstatz Hildebrand* and *Heimdall* are being delayed in order to instal upon them a heavier gun than the 12-inch as a reply to the 13.5-inch guns of the latest English ships.

WORLD'S FASTEST CRUISER.—An official communiqué is issued pointing out that the armored cruiser *Von der Tann*, on her latest trials, achieved a speed of 27.4 knots. This figure was obtained as the average speed of six tests on a 6-knots' measured course at Neukrug, where the depth of water is about 65 meters. The official records, however, show that the absolutely highest speed reached was 28.124 knots, the engines developing 80,000 horse-power. It may therefore be calculated that in water over 100 meters deep, with her engines working at full pressure, the cruiser has a speed of 28 knots.

According to the statements of Mr. McKenna, the First Lord of the Admiralty, in the House of Commons, the speed of British cruisers of the same class as the *Von der Tann* is: *Invincible*, 26.65 knots; *Indomitable*,

26.1 knots; and *Inflexible,* 26.5 knots. It can therefore rightly be said that the Von der Tann possesses a higher speed and greater engine power than any other armored cruiser, and therefore greater than any other ship in the world.—*Reuter.*

GERMAN AND BRITISH ARMORED CRUISERS.

Name of vessel	H. M. S. Lion.	Moltke.	H. M. S. Invincible	Von der Tann.	H. M. S. Defence.	Blucher.
Date of completion	1911	1911	1909	1910	1908	1909
Displacement, tons	26,500	23,500	17,500	19,200	14.600	15.250
Length	660 ft. pp.	600 ft.	530 ft. pp.	560 ft. W.L.	490 ft. pp.	499 ft.
Breadth	88 ft. 6 in.	91 ft.	78 ft. 6 in.	85 ft.	74 ft. 6 in.	80 ft. 3 in.
Speed, knots	(28 des.)	....	26.5	27.5 F. D.	23.5	25.3 F. D.
Horse power.....	70,000 des.)	....	45.000	70,000 F. D.	27,000	39.000 F. D.
Armament	8 13.5-in. (50 cal.) 16 4-in.	10 12-in. (50 cal.) 12 6-in. 16 3.4-in.	8 12-in. (45 cal.) 16 4-in.	8 11-in. (45 cal.) 10 6-in. 16 3.4-in.	4 9.2 in. (50 cal.) 10 7.5-in. 16 3-in.	12 8.2-in. .... 8 6-in. 16 3.4-in.

—*The Engineer.*

GREAT BRITAIN.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Neptune.....	20,250	Portsmouth.	Under trial.
Colossus	20,250	Scotts (Greenock).	Launched Apr. 9, 1910.
Hercules	20,250	Palmer's (Jarrow).	" May 10, 1910.
Orion.....	22,500	Portsmouth.	" Aug. 20, 1910.
Monarch	22,500	Armstrong.	Building.
Conqueror	22,500	Beardmore.	"
Thunderer.....	22,500	London (Thames Iron Works).	"
Armored Cruisers.			
Indefatigable.....	18,000	Devonport.	Under trial.
Lion.....	26,350	"	Launched Aug. 6, 1910.
Princess Royal	26,350	Vickers.	Building.
Australia.....	18,800	Brown & Co.	"
New Zealand.....	18,800	Fairfield.	"
Cruisers.			
Blonde	3,400	Pembroke.	Launched July 22, 1910.
Active.....	3,400	"	Building.
Amphion...	3,400	"	Ordered.
Dartmouth	5.250	Vickers.	Building.
Falmouth.....	5,250	Beardmore.	Launched Sept. 20, 1910.
Weymouth.....	5.250	Armstrong.	Launched Nov. 18, 1910.
Yarmouth.....	5,250	London & Glasgow Co.	Building.
10	5,250	Brown & Co.	Ordered.
11	5,250	Beardmore.	"
12	5,250	London & Glasgow Co.	"
13	5.250	Vickers.	"
14	5,250	Cammell, Laird & Co.	"

The *Orion* is the eleventh of the "all big-gun" vessels to be built for the Royal Navy. She is the last of the first four ships belonging to the navy estimates of 1909-'10, but she is different from the others, being the first of a new type. The sister vessels of the *Orion* will be the *Conqueror, Monarch* and *Thunderer.* The displacement of the *Orion* is about 22,500 tons. She has a length between perpendiculars of 545 feet, her

length over all being about 580 feet, and her beam 87 feet. The *Neptunes* are 510 feet by 85 feet beam, the *St. Vincents* 500 feet by 84 feet, and the earlier ships are 490 feet by 82 feet. The designed speed of all the ships is from 20¾ to 21 knots on trial. In the *Dreadnought* this speed was obtained with 23,000 horse-power; in the *Neptunes* the power rose to 25,000; in the *Orion* and her sisters 27,000 horse-power will be necessary. The armament of the *Orion* is to consist of 13.5-inch guns, and she will mount 10 of these guns, arranged in pairs in center-line turrets. The secondary armament will consist of a number of 4-inch guns, as in all battleships since and including the *Bellerophon.* It is stated that 16 of these guns will be mounted, but there may be more. In addition to carrying the most powerful gun yet mounted on a warship, the *Orion,* it is stated, will also have a bigger torpedo—a 21-inch weapon taking the place of the 18-inch torpedo hitherto used. She will be fitted with Parsons' turbines of 27,000 brake horse-power, and will have four propellers. She will carry 2700 tons of coal and 1000 tons of oil fuel.

The *Orion* is the heaviest ship ever launched from the building slip at Portsmouth, and no vessel has been sent afloat so far advanced in the matter of construction, so that, although she has been nearly 9 months in hand (the first keel plate was laid on November 29 of last year), no doubt is entertained that she will be completed for sea well within the stipulated 2 years. Her launching weight was 8500 tons. She is the fifth Dreadnought built at Portsmouth, and the launching weights of her immediate predecessors were 7500 tons in the case of the *Neptune* and 6800 of the *St. Vincent.—Page's Weekly.*

The *Orion* having been successfully launched, we now have afloat our first battleship with the whole of her guns mounted on the center-line. The tendency has, of course, been in that direction since the Dreadnought type was first introduced; in fact, the type itself is based largely on the fact that modern tactics demand broadside power before anything else. In the United States all ships of the all-big-gun type have been designed with full broadsides, and in each case the turrets—four in the *Michigans,* five in the *Delawares* and *Floridas,* and six in the *Wyomings*—are mounted on the center-line of the ship. There is no doubt as to the efficiency of the practice, and although we have seven Dreadnought battleships which are able to concentrate only eight of their ten guns on either broadside, the deficiency, for it seems to merit that name, has been remedied partially in the *Neptunes* and wholly in the *Orion.* It was seen from the first that as a ship is a compromise of sacrifices, so a broadside of a 100 per cent of the armament would only be obtained by a sacrifice in other directions. The *Neptune* is an apparent exception, for she can fire as many guns ahead as the *Dreadnought,* and two more (eight) astern; but on the other hand the echelon arrangement of the midship turrets, which alone makes this possible, is itself not the most advantageous for broadside fighting, since the port turret can cover only a small arc on the starboard beam and *vice versa.* The *Orion,* which has as efficient a broadside as we are likely to obtain—except, of course, in so far as a greater number of turrets may be mounted—is a better instance of the sacrifices demanded by a full broadside. She can fire only four guns ahead or astern to the *Dreadnought's* six, while the *Neptune,* which has the advantage of a superposed turret aft, can fire eight guns in that direction. Bow and stern fire, however, are well and wisely subordinated to the broadside.—*Naval and Military Record.*

The *Neptune,* the latest completed vessel of the Dreadnought type, has concluded her official steam trials at varying horse-powers, including a 30-hours' run at 17,500 horse-power, and with half and full boiler power. Her contract horse-power is 25,000. The full-power trials were carried out on the measured mile off the Cornish coast, where a mean speed of

21.5 knots was obtained, the vessel working up to a speed of 21.7. In an 8-hours' run up Channel, speed had to be eased down in consequence of the weather being thick. The vessel was engined by Messrs. Harland & Wolff, of Belfast, and is fitted with a new type of Yarrow water-tube boilers, which are provided with special feeding arrangements by which the water is introduced through the back row of tubes. This, it is claimed, gives an advantage of greater durability and economy. Though the speed attained was half a knot in excess of her contract speed, it is thought that this may be still further improved upon by fitting propellers of a slightly different pitch. The fuel consumption is regarded as satisfactory.—*Page's Weekly.*

THE "FALMOUTH."—The second-class protected cruiser *Falmouth* was launched on September 20 from the shipyard of Messrs. William Beardmore & Co., at Dalmuir. Viscountess Falmouth performed the naming ceremony. The keel of the *Falmouth* was laid on February 21, so that she has been advanced to launching stage in exactly 7 months. The turbine machinery and the boilers are in an advanced stage of construction, so that the *Falmouth* will be completed well within 18 months.

The *Falmouth* is the first of four sisters to take the water—the others being the *Dartmouth, Weymouth* and *Yarmouth.* They differ in some particulars from the original *Bristol* type, but belong to the same main class. The length is 430 feet in all, but in the later ships the beam and draft have been increased somewhat, being 48½ feet and 15½ feet in the *Falmouths,* as against 47 feet and 15¼ feet in the *Bristols.* Correspondingly, the displacement tonnage is increased from 4800 tons to 5250 tons. The speed in each case is nominally 25 knots. The *Bristols* have easily exceeded this on trial, exceeding also their nominal horse-power of 22,000. The greatest change from the original type is, however, in respect of armament. The *Bristols* carry only two 6-inch and ten 4-inch guns each, but the *Falmouths* are to be equipped with eight 6-inch, of which five will be available on the broadside. Beyond these they will have only four 3-pounders and some Maxims. Very considerable progress will be made with the whole of the class before the close of the present financial year, the total sum to be spent on the *Falmouth* before March 31, 1911, being £238,154, or, roughly, two-thirds of her cost. The *Dartmouth, Weymouth* and *Yarmouth* are to be similarly advanced, and the whole of them are expected to be ready for service in about a year from now.—*Naval and Military Record.*

The five City cruisers of the 1908-1909 programme have now completed their trials, and it appears that the *Bristol,* with Curtis turbines, has made the best maximum speed of all of them. Her mean speed on six runs over the measured mile was 26.84 knots, and on the 8-hours' trial at full power the mean power developed was 24,227 s. h. p. The speed is greater than that of either of the four sisters of the *Bristol,* which have the usual Parsons turbines, though no less than three of them worked up to higher power. For purposes of comparison the speed on the measured mile and horse-power on the 8-hours' trial are given as follows:

Ship.	Shaft horse-power.	Mean speed.
Bristol	24,227	26.84
Glasgow	22,500	25.8
Gloucester	24,335	26.296
Liverpool	24,718	26.171
Newcastle	25,417	26.266

The designed horse-power was 22,000, and the speed 25 knots; but, as will be seen, all the five cruisers may be reckoned as 26-knot vessels. The *Bristol,* it has been said, made a speed which is greater than the rate

attained by any British warship other than torpedo-craft; but this seems hardly correct, as all of the *Invincibles* are understood to have reached 27 knots either on trial or on service, while the *Boadicea* and *Bellona* exceeded 27½ knots on their full-power tests. But the *Bristol's* result is nevertheless highly satisfactory, and reflects great credit on the staff of Messrs. John Brown & Co., whose proposal it was to equip the ship with the Brown-Curtis turbine, of which they hold the rights in Great Britain. The *Bristol,* it may be noted, is a twin-screw vessel, unlike all the other turbine-driven ships in our navy, which have four propellers. This is an advantage of the new turbine, with which it is also possible to vary the power as required, thereby doing away with cruising turbines, which are a feature of the Parsons system.—*Army and Navy Gazette.*

The Admiralty have placed orders for five cruisers of the *Yarmouth* type, as follows: One each with John Brown, Limited, Clydebank; Beardmore & Co., Dalmuir; the London & Glasgow Engineering Co., Govan; Cammell, Laird & Co., Birkenhead; and Vickers, Sons, & Maxim, Barrow. All except that built at Clydebank will have Parsons turbines. The Clydebank boat—like the *Bristol,* which is now completing, after successful trials—will be propelled by Brown-Curtis turbines. It is announced that three of these cruisers are for the colonies, one each for Australia, New Zealand and Canada.—*The Engineer.*

STEAMING EFFICIENCY.—Some remarkably good steaming was performed by the *County* and *King Alfred* classes during the recent maneuvers, the trial trip speeds being attained and kept up for long periods. Coaling was specially frequent, and in addition to full bunkers, nearly all the ships detailed for scouting duties carried a large deck load, which rendered them extremely uncomfortable from the point of cleanliness and convenience. But of all the ships, the turbine-driven battleships and cruisers were by far the best. The *Invincible* made a remarkable run, exceeding her trial speed for many hours together. She is by far the fastest of the class, the *Inflexible* being at least 1½ knots slower, and the *Indomitable*—in spite of her famous run across the Atlantic—still more so. The *Temeraire,* among the battleships, did very well, but she has been carrying out an extensive series of propeller trials, and now presumably possesses the best.

NEW STEAMERS.—The comparatively recent adoption of 50-foot steamboats for the larger vessels of the fleet in place of the older 56-foot type has certainly been a good thing for the constructors, as it has enabled them to reduce a good deal of weight in derricks, chocks, etc. But it has not met with the unqualified approval of the users, who have to exist in them far oftener than is generally supposed, as they are neither as fast or as seaworthy as the older boats. In the German Navy motor-boats have been widely introduced, and their speed leaves nothing to be desired. In fact, Kiel Bay is a very interesting sight when several of the larger ships are lying there, as the constant and very rapid movements of the attendant picket boats give an air of great animation to the whole surroundings.

LENGTH OF FUNNELS.—The lengthening of funnels to increase the draft in the stokeholds has often been resorted to at home and abroad, but in this country more than any other has it been done to obviate the smoke nuisance. Many of the earlier destroyer funnels were lengthened both for this purpose and to reduce flaming. Now the appearance of the *Indomitable* and *Warrior* is really extraordinary, for the forward funnel only in each case has been greatly lengthened to prevent the smoke affecting the navigating bridge. This was a great objection in these classes, and the modification will probably be extended to the sister ships. The

Indefatigable is also arranged in this manner. The *Shannon* and *Defence* had all their funnels lengthened recently, and the later Dreadnoughts would be improved by the same change.

H. M. S. *Bedford,* while carrying out full-speed trials on August 21, grounded on Samarang Rocks, off the island of Quelpart, at the entrance to the Straits of Korea, and 18 men, mostly stokers, lost their lives through the inrush of water. The remaining officers and men have been taken off the ship. H. M. ships *Minotaur* and *Monmouth* were anchored near the *Bedford,* but owing to heavy weather had to put to sea for the night. H. M. S. *Flora* has been ordered from Hongkong, and the Japanese authorities are lending assistance, but the commander-in-chief on the China Station reports that there is very little chance of salving the ship, which is full of water up to the engine-room bulkhead. The *Bedford* is one of the 23-24-knot armored cruisers of the *County* class, and was completed at Fairfield in 1903, and refitted in 1906. She has Belleville boilers and reciprocating engines. Her mean draft is about 24½ feet.—*The Engineer.*

NEW DESTROYERS. *Historic Names Revived.*—The 20 torpedo-boat destroyers belonging to the current year's programme have received their names. The tenders for their construction were placed some time ago—for 6 of them at the end of May, and for the remaining 14 early in June. The dimensions of the type are approximately, if not quite, the same as those of the *Acorn* class, belonging to the 1909-1910 programme, viz., 770 tons displacement, 27 knots speed, with an armament of two 4-inch and two 12-pounder guns each.

With reference to the names given to the vessels, *The Times* says: "The authorities, while handing on to the majority of the new boats the names of vessels which have but recently disappeared from the *Navy List,* have at the same time revived others connected with some notable exploit in our naval annals.

"The first name, *Acheron,* was originally that of a bomb-vessel of eight guns, which took part in the blockade of Toulon in 1804, and in the next year was with the *Arrow,* 28, in charge of convoy when attacked by the *Hortense* and *Incorruptible,* of 40 and 38 guns, respectively. The English ships were captured after a heroic defence, but were so damaged as to be useless.

"The name *Archer* also was first borne by a three-gun vessel in 1804, and a few months later by a 14-gun brig which in 1805 captured two French gunboats off Cape Griz Nez. It was next given to a screw ship of 14 guns, which served in 1851 at the capture of Bonbee (Benin River), in the Baltic campaign of 1855, and in operations against pirates on the Congo 10 years later. The last *Archer* was a protected cruiser, launched in 1885.

"The name *Ariel* dates from 1777, having been first given to a 20-gun ship which captured in 1779 the French *Amazone,* of 26 guns, after an action lasting an hour and a half. A screw ship of the name took part in the war with Russia, and in 1857 was instrumental in the suppression of piracy in the Persian Gulf. In 1862-1864 she captured 18 slavers on the East Coast of Africa. There was also a gunboat of this name in the Congo and Niger expeditions in 1875-1876.

"The name *Attack* is not so well known, having apparently been borne by only one vessel, a gunboat, which in 1809 assisted in storming the battery at Doëlan, in Brittany, in the cutting out of two chasse-marées and in the destruction of a signal station. She was afterwards attacked herself by a flotilla of Dutch gunboats, and captured in a disabled condition after a strenuous defence.

"The first ship to be called the *Badger* figured in 1745 in operations against smugglers, when she captured two vessels. The next *Badger,* a

14-gun sloop, was in the blockade of Dunkerque, while another ship of this name took part in the operations connected with the occupation of St. Marcou in 1798 and 1799. There was also a gun-brig known as the *Badger* in the Baltic in 1855, while the last of the name was a gunboat built in 1872.

"*Beaver* has been missing from the *Navy List* for more than a century. A 14-gun ship of the name captured an American privateer in 1777, and a later *Beaver*, of 18 guns, took part in 1804, in the cutting out of the Dutch *Athalante* from the Vlie.

"There has been but one *Defender* in the navy, a ship of 12 guns, and in 1799 her boats took part in the cutting out of four Dutch gunboats on the coast of Holland. She was wrecked near Folkestone 10 years later.

"The first ship to be known as the *Druid* was one of the squadron at the capture of Belle-Isle in 1761. She had a successor which, while on convoy duty in connection with the homeward-bound trade from the Leeward Islands, successfully beat off the attack of the famous American frigate *Raleigh*. Yet another *Druid* was with the *Crescent* and *Eurydice* in 1794 when those ships engaged the French *Scevola* and *Brutus*, 50-gun ships, two other 36-gun frigates, and a brig. In 1797 she assisted at the capture of the *Ville l'Orient* off the Irish coast, and in the next year was in the expedition to Ostend. Nor did this exhaust her services, for she was present during the operations on the coast of Egypt in the summer of 1801, and 8 years later she captured the 16-gun ship *Basque*. Another *Druid* of 44 guns took a conspicuous part in the first China War (1841), while the last of the name was a 10-gun corvette built in 1869 at Deptford, and probably the last ship built at that yard.

"*Ferret* has an interesting but unfortunate history as a warship name. The first *Ferret* was a sloop of 10 guns, which was lost to the French in 1706. The next, of 14 guns, foundered off Louisbourg in 1757. Five years later another *Ferret* was at Martinique and the reduction of Havana, but this vessel also was lost in the West Indies in 1776. In 1778 there was a galley known as the *Ferret* in the battle between Howe and d'Estaing. Her successor, an 18-gun vessel, took part in the capture of the French *Mosquito* on the Jamaica Station in 1807, but in 1813 was wrecked near Leith. The sixth vessel of the name was a brig-sloop which was wrecked off Dover in 1869; and it was not until 1893 that the name was given to a destroyer, which boat has recently been withdrawn and ordered to be broken up at Chatham.

"*Forester* is a name of some antiquity, the first being built in 1657, but no war services are credited to her. It was 150 years before another *Forester* came into being, this vessel carrying 18 guns. A screw gun-brig of the name was in the affair in Fatshan Creek in 1857, and in the attack on the Peiho and Taku forts in 1859. The last *Forester*, a composite gunboat of 455 tons, landed men for the Zulu war in 1878.

"The name *Jackal* was borne between 1779 and 1807 by four small craft which did useful service, and in 1851 was given to a paddle ship of 340 tons, which was at the capture of Bonbee (Benin River).

"*Goshawk* has had but one representative, of 16 guns, which, after much useful service, was wrecked in 1813.

"*Hind*, on the other hand, is a very ancient name, dating back to 1545, and a coast-guard cruiser, lost in 1900, was the last to bear it.

"*Hornet* was first the name of a 14-gun vessel, which was lost to the French in 1744, and retaken in the same year, since which date it has been successively borne by a 16-gun ship, an 18-gun ship-sloop, and a screw ship of 17 guns, which was at Fatshan Creek and the bombardment of Canton.

"The name *Hydra* was given to a famous 38-gun ship in 1778, and the last to bear it it was an armor-plated turret ship, launched in 1871.

"*Lapwing*, now the name of a gunboat on the sale list, was first given to a 28-gun ship, which in 1796 fought a gallant action with the *Decius*

and *Vaillante,* of 20 and 10 guns, respectively, and captured the former. There was also a screw ship of this name which in 1869 was employed in intercepting the blockade runners bound for Cuba.

"*Lizard* is the oldest of the 20 names, the first to bear it being a ship of 120 tons, built in 1512, since when several small craft have borne it down to a gunboat of 1887.

"*Phoenix* is likewise an old name, dating from 1546, and is associated with many valuable services. The last *Phoenix,* a twin-screw sloop, contributed a landing party towards the brigade which marched to the relief of the Peking legations in 1900, and in 1906 she was blown ashore and wrecked during a typhoon at Hongkong.

"Three ships have been known as the *Sandfly,* the first in 1798 capturing the *Flibustier* with the aid of the *Badger,* while the last *Sandfly* was a gunboat launched in 1887.

"Last, and least famous, is the name *Tigress,* which appears to have been borne by only one vessel, a 12-gun brig, which saw service in 1807 at Copenhagen."—*Naval and Military Record.*

ARMORED CRUISER DESIGN.—The salient features of the armored cruiser *Lion* indicate developments in design which suggest changes of view on the part of our naval authorities. We are not concerned for the present with the tactical reasons for the demands upon the naval designer—in this instance for exceptionally high speed in cruisers in association with a power of attack hitherto adopted only in relatively slow battleships. The question of interest to the marine constructor is the effect upon design in the attaining of these results. Only a few years ago the naval officer, for instance, regarded with misgiving any proposal to increase the length of the ships, because the area of the target presented to the enemy was augmented. Thus, up till 1901, the maximum length of any capital ship in the British Navy—and we might almost say also in all fleets—was 400 feet, and even in the case of cruisers the exceptional length of 500 feet given to the *Powerful* and *Terrible,* which were designed essentially for speed, was regarded unfavorably by some for the reason stated. The naval architect longed for the freedom given to the designer of merchant ships, because great length enables high speed to be achieved more easily than with a short ship. The *Dreadnought* marked a development, and the successive cruisers, with gun-power corresponding to battleships, have shown this evolution still more markedly. The greater range of combat probable in the future may have induced the naval tactician to waive his objection to the larger target; but the change in the armament, as well as the craving for higher speed, have been dominant influences towards the acceptance of greater length. In any case it is a subject for satisfaction that the limitations imposed on the naval designer are now less stringent, although not by any means entirely removed, as the unprecedented lengths of the later naval ships are conducive to high efficiency in respect not only of speed, but also of convenience in effectively disposing the guns.

The increase in the number of primary guns carried has called for careful consideration regarding the emplacement of these guns in order that they may be utilized to the fullest possible extent. First, as to the number of guns, the Admiralty seem to have made up their mind that eight guns disposed in pairs in four barbettes represent a reasonable compromise for such cruisers. This decision has been criticised because 10 guns are mounted in battleships having a length far short of the 660 feet, between perpendiculars, of the *Lion.* It must, therefore, be accepted that the personal equation—the ability of the captain to control so many guns—has not influenced the Admiralty, although the time may come when the psychological question must obtrude itself. We doubt, too, whether considerations of weight have had much influence except in so far as they affect the size and speed of the ship. An additional twin-gun turret, with

guns, mountings and armor, would of itself weigh about 630 tons; but in order to accommodate this without increasing the draft the length and breadth of the ship would require to be augmented, and the consequent increased displacement would demand higher engine-power for a given speed, so that the weight of machinery would be greater. These elementary facts are stated because they are too often forgotten; any slight addition to the load carried involves an increase in size, power and machinery for the same speed, which in the end multiplies the primary additional weight three to five times.

The Admiralty, therefore, instead of increasing the number of guns, have preferred to increase their size. It will be obvious to the student of naval development that the aim in fitting a gun of increased bore is not so much to attain a higher striking power; the muzzle energy will probably be only slightly over 60,000 foot-tons, an increase of about 10 per cent; but the important point is that the larger shell will accommodate a considerably greater bursting charge, so that when the shell reaches its billet it will have enormously increased destructive effect. The 12-inch gun is adequately efficient so far as concerns its penetrative power at reasonable fighting range. The 13.5-inch gun, with its greater energy, will nullify recent improvements in the resisting power of armor, so that the total gain is the larger bursting charge. The hydraulic mountings have been improved, and there will be no reduction in the rate of fire. In addition to the eight guns of the primary armament, the *Lion* will carry sixteen 4-inch guns, and will have submerged tubes for the discharge of the largest torpedoes made.

By limiting the number of guns to eight and the number of barbettes to four, it has been possible to considerably improve upon the arrangement of these guns as a consequence of the greater length. In the ships of the *Invincible* class there was a bow and a stern barbette, the two pairs of guns amidships being placed in *echelon,* so that they are utilizable on either broadside. This arrangement, although favored by many, and adopted in several capital ships, has its disadvantage, and in the new cruisers, as well as in the later battleships, the barbettes for the large guns are all placed on the center-line. The second and third pairs of guns from the bow are at a higher level than the others, so that four guns may fire ahead and four astern. The general disposition of the guns interferes with the arrangement of the machinery in order that the magazines could be located under the turrets—an arrangement which involves much greater difficulty in the case of a cruiser, having boilers to supply steam to maintain something like 70,000 shaft horse-power in the turbines. This difficulty, indeed, largely influences the number of guns adopted. The casual visitor to a battleship sees an enormous area of upper deck, which seems available for guns of large and small bore, forgetting that, from the upper deck downward, the area required for uptakes from the boilers and ventilating shafts for machinery rooms absorbs much space; and that the guns are of little use unless well-protected magazines are adjacent to them, and liberal room allocated for ammunition hoists. The adoption of four turrets in the *Lion* was therefore a wise compromise, in view of the speed demanded. The armor protection provided for extends from the upper deck to about 7 feet below the load water-line, and not only covers a greater area relative to the length of the ship than in the *Invincible,* but will have about 30 per cent more resisting power.

It is not without interest to consider the effective horse-power required to propel ships of different lengths at a given speed, because there is thereby established not only the advantage of the greater length of the *Lion,* but the difficulties under which Admiralty designers have hitherto worked, in comparison with the relative freedom of the designer of merchant ships. It has been put on record, for instance, that with the limitations imposed by other considerations—such as passenger accommodation, etc.—the *Lusitania* and *Mauretania* could not have been built on a re-

stricted length of 700 feet, instead of 760 feet, to cross the Atlantic at the speeds they have attained. The power, if the lesser dimension had been adopted, would have gone up at least 10 per cent, and could not have been installed in the space available. The *Invincibles* are 530 feet, the *Indefatigable* 555 feet, and the *Lion* 660 feet, between perpendiculars. The displacement has gone up from 17,250 tons to 26,350 tons. Assuming a speed of 27 knots for all three vessels, the effective horse-power per ton of displacement in the case of the *Invincible* is 1.7, in the *Indefatigable* 1.58, and in the *Lion* is 1.43. It will thus be evident that the increased length, with the same weight of machinery and the same power, adds materially to speed. The *Lion,* however, will probably materially exceed 27 knots, and the gain will be still more marked.

It is only right to say that such high speed has been rendered possible only by the invention of the turbine, because the steam consumption for this type of machinery is so much less than with the best reciprocating engines yet constructed for naval work.—*Engineering.*

PROTECTED CRUISERS. *Modern Vessels and the Trend of Policy.*—The protected cruiser is one of the few classes of warships which have not been affected by the expansion of displacements. Before the era of the *Dreadnought,* protected cruisers had been built of 11,000, and even, in the case of the *Powerful* and *Terrible,* of 14,200 tons, approaching very close to the tonnage of contemporary battleships. To take a few concrete instances from our own fleet, we find that in 1891 and 1892 there were launched the 14,150-ton *Royal Sovereigns* and the 7350-ton *Edgars,* as well as the *Crescent* and *Royal Arthur,* of 7700 tons, so that the protected cruisers displaced rather more than a half of contemporary battleships. The 14,900-ton *Majestics* were launched between 1894 and 1896, during which period five classes of protected cruisers were launched. First came the *Diana* class (1894-1896) of 5600 tons. In 1895 the *Powerful* and *Terrible* took the water, built under the mistaken idea that such ships would be a match for the armored cruisers whose construction had then been undertaken on the Continent. The *Arrogants* (5750 tons) and the *Diadems* (11,000 tons) followed in 1896-1897, while the "*P*" class (2135 to 2200 tons) were spread over the period 1896 to 1900. The *Diana* class were considerably smaller in proportion to the *Majestics* than were the *Edgars* compared with the *Royal Sovereign;* but, on the other hand, the *Powerfuls* were actually 50 tons larger than the *Royal Sovereigns,* and approached to within 700 tons of the contemporary *Majestics.* The next batch of battleships fell off considerably in displacement, the *Oceans* measuring only 12,950 tons. These six ships were launched in 1897-1899, a period which included some of the "*P*" class as well as some *Arrogants* and *Diadems,* together with the three *Highflyers* and the four *Argonauts.* The displacement of these cruisers ranged from 2135 to 11,000 tons, the smallest equalling about one-sixth and the largest about five-sixths of the size of the battleships. In 1898-1899, however, the *Formidables* also were launched, so that the cruisers mentioned, with the exception of the *Arrogants,* come also into comparison with them. The *Formidables* were approximately of the same tonnage as the *Majestics;* but it is at once evident that a considerable change had come over our cruiser policy. The *Majestics* had synchronized with the two main types, the 14,200-ton *Powerfuls* and the 5600-ton *Dianas.* When we come to the *Formidables* we find the largest type represented by the *Argonauts,* 3200 tons smaller than the *Powerfuls;* that the new *Highflyers* were of the same displacement as the earlier *Dianas;* and that a third and smaller type, the "*P's,*" had by now been produced in comparatively large numbers. The *Pelorus* and her sisters have been much criticized, but when, after a brief lapse, we returned to the construction of cruisers, it was essentially from this type, with an additional 1000 tons devoted to speed and endurance, that the model was taken.

The year 1901 saw the launching of the *Albemarles;* but there were no protected cruisers launched in that year. For some time, indeed, we practically ceased to build these vessels, apparently relying on armored cruisers to do the work with which they had previously been invested.

PROTECTED CRUISER DISPLACEMENTS.

(*Showing relation to that of contemporary battleships.*)

			Average.
1891–2.	R. Sovereign (14,150) ..100	Edgar (7,350) .....51.9 Æolus (3,400) .....24.0 Crescent (7,700).....54.4	43.4
1894–6.	Majestic (14,900).....100	Powerful (14,200).....95.3 Diadem (11,000) .....73.8 Arrogant (5,750) .....38.6 Diana (5,600) .....37.6 Pelorus (2,200).....14.8	52.0
1898–9.	Formidable (15,000)....100	Argonaut (11,000).....73.3 Hermes (5,600) .....37.3 Pelorus (2,200).....14.46	41.7
1902.	Queen (15,000) 100	Challenger (5,915).....39.4	39.4
1903–4.	King Edward (16,350)..100	Topaze (3,000) 18.3	18.3
1908.	Neptune (19,900) 100	Bristol (4,800).....24.1	24.1
1909.	Thunderer (22,500).....100	Yarmouth (5,100) 22.7	22.7

In 1902 the *Challenger* and *Encounter* were launched, contemporaneously with the *Queen* and *Prince of Wales,* the respective displacements being 5915 and 15,000 tons. Compared with the cruisers of the *Formidable* period, the largest and smallest types had both gone, leaving to the middle size a small accession of displacement. There was still, however, a hankering after smaller ships more or less on the lines of the *Pelorus,* and in 1903-1904, although the tonnage of battleships was increased to 16,350 in the *King Edwards,* the four ships of the *Gem* class were given only 3000 tons. Compared with the *Pelorus,* 865 tons smaller, they had a slightly greater coal supply, 1.25 knots more speed, and four more 4-inch guns. Both classes have a 2-inch deck.

From 1904 to 1907 no unarmored cruiser was launched for the fleet, although in that period seven battleships and three battle-cruisers were provided for. The first ship of the new series was the *Boadicea,* of 3300 tons; but although 1000 tons larger than the *Pelorus* class she has no armor whatever, and carries six 4-inch guns as against eight. The additional tonnage is wholly absorbed by the increased speed of 25 knots and by the much better coal supply of 450 tons normal. The first protected cruisers properly so-called to be launched after the *Gems* were the *Bristols,* now passing into service. Provided for in the same year as the *Neptune,* they displace 4800 tons, compared with the 19,900 of the battleship, and thus, with the exception of the *Gems,* are proportionately smaller compared with the contemporary battleship than has ever been the case before, for although the *Pelorus* class were built during the *Majestic-Ocean* period, they were accompanied by the *Eclipses, Powerfuls, Arrogants, Diadems, Highflyers* and *Argonauts.*

The principal details of the *Bristols* are: Designed speed, 25 knots; coal, 800 tons; armament, two 6-inch and ten 4-inch. They were followed in 1909-1910 by the four ships of the *Yarmouth* class of 5100 tons, carrying a uniform armament of eight 6-inch guns, steaming 26 knots, and carrying 1000 tons of coal.

At the end of this article will be found a table in which the principal characteristics of all recent protected cruisers, so far as they are known, are reduced in the case of each of those characteristics to a common scale. It will be seen that on most points the vessels which Germany is building to replace the *Buzzard* and *Falke* head the list; but it must be pointed

out that the accepted details are not in any way official. The figures taken in the case of those ships are: Displacement, 5500 tons; speed, 28 knots; armament, two 5.9-inch and ten 4.1-inch; coal capacity, 1250 tons. In the case of the other vessels it is unnecessary to give here a list of details which can be obtained from any current work of reference. It cannot fail to be noticed, however, that there is still a wide discrepancy in the practice of the various powers in protected-cruiser design, and that on the whole, and particularly making allowance for the unofficial nature of the figures accepted for the *Ersatz Buzzard,* British types occupy a quite satisfactory position. The feeble gun-fire of the U. S. S. *Salem* and the Austrian *Spaun* stand out conspicuously; and, with the certainty that the Italian *Quarto* will not be more powerfully armed than the *Bristol,* it will be seen that no fewer than six of the nine vessels listed fail to reach within a third of the standard set by the *Yarmouth.* In speed there is not a great deal to choose, although it must be remembered that the difference between the 100 of the *Ersatz Buzzard* and the 85.7 of the *Salem* is a difference of 4 knots. In coal the *Salem* and *Ersatz Buzzard* lead with 1250 tons apiece. The Brazilian *Bahia,* holding a good place for speed and a medium one for gun-fire (considering her displacement, as will be seen from the "Gun-fire per Ton" column), has sacrificed coal to a great extent. Generally speaking, the "Average" column follows the displacement. The exceptions are the *Quarto,* whose place would probably not be so high but for the fact that her armament and coal supply are unknown; and the *Kolberg* and *Bristol,* in which cases fair speed and displacement are counter-balanced by inferior gun-fire in the case of the *Kolberg* and by that combined with a poor coal supply in the case of the *Bristol.* For purposes of comparison the details of the *Diana* and *Æolus* are added:

Ship.	Tonnage.	Speed.	Coal.	Gun-fire.	Avge.	Gun-fire Per ton (lbs.)
Ersatz Buzzard	100	100	100	75.5	93.9	.11
Yarmouth	92.7	92.8	80	100	91.4	.157
Chikoma	90.9	92.8	?	81.25	88.32	.13
Tone	74.5	82.1	?	81.25	79.28	.159
Quarto	60.0	98.2	?	?	79.1	?
Kolberg	76.9	91.0	80	57.0	76.2	.168
Bristol	87.3	89.2	64	63.75	76.06	.106
Salem	68.1	85.7	100	25.5	69.8	.054
Spaun	63.6	92.8	?	33.25	63.22	.076
Bahia	56.3	94.6	40	56.25	61.79	.145
Diana	101.8	69.6	86	151.0	102.1	.216
Æolus	65.4	71.4	42.8	58.75	59.59	.130

In all but speed it will be seen that the *Diana* class are well ahead of the *Yarmouths,* the superiority in gun-fire being in particular strongly marked. This is the more noticeable because there is such a small difference in the displacements—5600 tons for the *Diana* and 5100 for the *Yarmouth.* In fact, regarding the figures more closely, we might almost say that the *Yarmouth* will be an *Eclipse,* which has sacrificed three 6-inch and nine 3-inch guns in order to secure an additional 6½ knots speed. That sacrifice was, of course, essential in view of the trend of speeds in recent years. At the same time, the speed of the small cruiser has increased in a greater ratio than that of the battleship. Here are some instances from the cases given in the first table, contemporary vessels being taken in each case: 1891-1892, *Royal Sovereign* (17.5 knots), 100; *Edgar* (19.5 knots), 111.4. 1894-1896, *Majestic* (17.5 knots), 100; *Diana* (19.5 knots), 111.4; *Powerful* (22 knots), 125.7. 1897-1899, *Ocean* (18.25 knots), 100; *Hermes* (20 knots), 109.6; *Argonaut* (20.25 knots), 110.9. 1902, *Queen* (18 knots), 100; *Challenger* (21 knots), 116.6. 1903-1904, *King Edward VII* (18.9 knots), 100; *Topaze* (21.75 knots), 115.1. 1908-

1909, *Neptune* (21 knots), 100; *Bristol* (25 knots), 119. 1909-1910, *Hercules* (21 knots), 100; *Yarmouth* (26 knots), 123.8. It will be seen that from being about one-ninth faster than contemporary battleships the protected cruiser has now an advantage of about one-fourth.

Armaments appear to be working in a circle. The *Edgars* and *Crescents* had 9.2- and 6-inch; the *Hermiones* followed with 6-inch and 4.7's. The *Powerfuls* were the last protected cruisers to have 9.2-inch. The *Diadems* and *Arrogants* carried all 6-inch, as did also the *Highflyers, Argonauts* and *Challengers.* The *Gems* marked another drop to 4-inch, and we might include the scouts and say that the lower limit was reached in them with the 12-pounder. The *Boadicea* marked the first recovery with six 4-inch, then came the *Bellona,* with ten 4-inch. The *Bristols* have two 6-inch and ten 4.7-inch, and the *Yarmouths* advance higher to eight 6-inch.

Orders have recently been given for some 9.2-inch guns. What is to be done with them has not been divulged; but, as on the resurrection of the protected cruiser in 1908, the new vessels were referred to as "improved *Edgars,*" it would surprise no one if that excellent weapon again took a place in the armament of protected cruisers. That is certainly the trend of modern practice.—*Naval and Military Record.*

AGE OF ENTRANCE FOR NAVAL CADETS.—The new naval training scheme continues to meet with criticism, and the fusillade comes from quite unexpected quarters. In *The Lancet* a correspondent suggests that cadets should enter Osborne not earlier than their sixteenth year. He advances arguments which to the landsman will appear reasonable and logical. He points out that boys of 13 are not selected at that early age specially to be judges, bishops, doctors, poets, musicians, painters and sculptors, and claims that 90 per cent of the medical and military men, heads of factories, railways and mercantile firms would agree that it is almost impossible to ascertain by physical and educational examinations of boys of 13 years of age what they will turn out to be at 16 to 18 years of age, still less what will be their moral qualifications between 20 and 30 years of age. In this correspondent's opinion, too, the influences of heredity, whether good or bad, are often undeveloped before the age of 13 to 15, but nearly always become markedly developed by 16 years of age.

All these arguments may be thoroughly logical, but they do not apply in this case. In selecting cadets at an early age the navy acts by instinct, and that instinct is justified by tradition. The correspondent of *The Lancet* apparently knows nothing of the tradition of the fleet. He does not know that every one of the convincing points which he makes against early entry can be swept aside by the fact that, except for a short period during Lord Goschen's administration of the navy, when the age was somewhat raised, naval officers have always been entered at an early age. The policy has always been to catch them young. Nelson went to sea when he was 12 years old, the late Sir Henry Keppel was entered for the navy when he was only 11 years of age, and very much the same experience fell to all his contemporaries. The experience of the navy is all in favor of early entry, and 99 officers out of a hundred of the old school probably still believe firmly that the sooner the officer of the future gets away from the land and becomes familiar with sea conditions the better for his future. It is only by catching boys young that the Admiralty can get the time to give them 4 years of specialized training and general education before they go to sea. If the age of entry were advanced to 16 years, either the special training would have to be abandoned or the young officers would not much more than smell the sea before they were 20 years of age.

The correspondent of *The Lancet* argues that the selection of cadets at a later age would be preferable in the national interests, and here the views of an eminent but anonymous surgeon are quoted in support of the theory. To those familiar with the organization of the Royal Navy it will be evident that *The Lancet's* correspondent has got out of his depth.

The entry of cadets at an early age does involve the arrest of general education in favor of professional and technical training, but there is no ground for believing that we should obtain better officers if we tried the experiment of entering cadets at the age of, say, 17, from the public schools. In such mathematics as bear upon his career the naval officer is well grounded, and although it is an advantage for a modern officer to be familiar with French or German, few will seriously contend that knowledge of the classics is essential to a sea officer. The fact is that the naval officer must be a specialist, and it takes him all his time, from the age of 13, to study his profession in its several branches from gunnery to navigation, and from torpedo work to strategy. In effect the efficient naval officer is always learning from the day he joins Osborne College until he hoists his flag. No system of education produces ability, and the uses of education are still widely misunderstood.—*Naval and Military Record.*

NAVAL SIGNALLING.—With the progress and more extended use of wireless in the navy the merging of the new wireless branch with the old signal branch was bound to come sooner or later, and the Admiralty circular recently issued on this subject will therefore surprise nobody. The circular states that the Admiralty are satisfied that it is essential for the harmonious working of the signal department that the two branches should be co-ordinated under one head, who shall be responsible for the efficient transmission and receipt of all communications on board, whether by the visual signalling methods or by wireless. It is therefore decided that in future the control of all signalling is to be vested in the signal lieutenant, or if no officer of this grade is borne, in the signal boatswain as the senior signal rating. He will be held responsible for every signal made or received by the ship, but not for the efficiency of the actual means used for transmission by wireless telegraphy; that is to say, he will be responsible for the receipt from and report to the admiral or captain of all signals, and the logging of these; the transmission of signals by the proper route, and in the proper sequence, according to their urgency; for knowing whether a signal has or has not been despatched, and dealing with it in the latter case; and for keeping the wireless office informed of the movements of ships. The circular proceeds to deal with the new arrangements by which the signal officer is to have access at any time to the wireless office, and is entitled to give orders to the telegraphists respecting the sequence in which signals are to be made, and kindred matters. For all other purposes, including their exercises and training in the use of wireless, the telegraphists are to remain under the torpedo officer or officer in charge of electric gear. The new regulations therefore make clearer the limits of responsibility of the signal and wireless officers, who will in future occupy their rightful positions as indicated by their titles, the latter being only concerned with effective provision of the mechanism for signalling by wireless, and the former with its use for that purpose.—*Army and Navy Gazette.*

HIS MAJESTY'S "JOLLIES."—The Admiralty have been doing much during the last few years to improve the conditions of service for the officers and men in both divisions of the Royal Marines. The employment of Royal Marine officers in various naval duties has been widely extended and is still extending. Their connection with the wireless telegraphy department is firmly established, and officers selected for this work are very keen on their job; while the manner in which the second-class cruiser *Indefatigable* was run for a whole commission, chiefly by marines, on the West Indian Station, is notorious among men of the senior service. This work is not only appreciated by the officers and men themselves, but has considerably enhanced their value to the navy and the nation. The Admiralty also realizing that there has been some injustice and inequality in the rates of promotion, as between the officers of the Blue and Red

Corps, respectively, resulting from the division of the officers into two separate lists by the arrangements of 1863, have now granted some relief to those who suffered most. An Order in Council has therefore been issued directing that when officers of the Royal Marine Artillery and Royal Marine Light Infantry are serving together in the performance of duties peculiar to the corps, brevet rank granted for length of service shall take rank and precedence with corresponding substantive rank according to the date on which they were conferred. Needless to say this order has given great satisfaction to those whom it chiefly concerns.—*United Service Gazette.*

BRITAIN'S PIONEER AIRSHIP.—Our Barrow correspondent has been able to glean some particulars concerning the naval airship now in course of construction by Messrs. Vickers, Sons, & Maxim. The new airship will be the largest, fastest and most powerful yet constructed. Its gas-containing body is built up rigidly with a new metal, named Duralumin. This material has been patented by Messrs. Vickers, and the firm are now engaged erecting a factory at Birmingham for its manufacture on a large scale. It is only a trifle heavier than aluminium, but far stronger. The vessel will be 500 feet long and 50 feet in diameter. Her size will enable her to raise into the air a weight of close upon 20 tons. Her two 200-horse-power petrol engines, which have been subjected to severe tests for reliability, will give her a considerable speed through the air—probably 45 to 50 miles an hour under fair conditions.

The airship will also be fitted with wireless telegraphy. Her commander will be Lieut. Neville F. Usborne, R. N., a young officer who has made a special study of aeronautics. Lieut. Cecil P. Talbot, R. N., who will be attached to the airship staff, is also an ardent and clever student in matters relating to aviation. Besides the huge garage or hangar erected at Barrow, some 600 feet in length by 100 feet in width, the second-class cruiser H. M. S. *Hermione* has been appointed the parent ship, and is now docked at Barrow nearby. It may be taken as absolutely authentic that the airship will not be launched before Christmas, and probably not until the early part of 1911.—*Naval and Military Record.*

ITALY.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Dante Alighieri	19,000	Gov't Yard, Castellamare.	Launched Aug. 20, 1910.
Cavour.	22,000	" " Spezia.	Building.
Giulio Cesare	22,000	Ansaldo-Armstrong.	"
Leonardo da Vinci ...	22,000	Genoa (Odero).	"
Armored Cruisers.			
San Giorgio.....	9,800	Gov't Yard, Castellamare.	Under trial.
San Marco	9,800	" "	" "
Georgios Averof.....	9,800	Leghorn (Orlando).	Launched Mar. 12, 1910.
Scouts.			
Quarto.....	3,400	Venice.	Ordered.
Marsala	3,400	Castellamare.	"
Nino Bixio.....	3,400	"	"

The battleship *Dante Alighieri* was launched at Castellamare on August 20, being the first of the four Dreadnoughts comprised in the programme of Admiral Mirabello. The second is in hand at Spezia, being the *Conte di Cavour,* while the *Leonardo da Vinci* and *Giulio Cesare* are being built by Ansaldo & Odero. The *Dante* is to be completed in the first half of 1912, and the others may join the squadron at the beginning of 1913.

The *Dante* has been carried forward with great rapidity, 500 tons of material being built into the ship per month. Her machinery has been constructed by the Ansaldo Armstrong firm of Sampierdarina. She has been constructed from the plans of Signor Edoardo Masdea. The *Popolo Romano* gives the following characteristics of the ship: Length, 505 feet 3 inches; beam, 69 feet 10 inches; displacement, 18,000 tons; mean draft, 27 feet 3 inches. There will be twelve 12-inch 46-caliber guns in four barbettes, with electro-hydraulic mountings. The secondary armament will consist of twenty 5.9-inch 50-caliber guns, eight in a casemate and twelve on pedestal mountings. In addition there will be two torpedo tubes. The turbine engines will have 26,000 horse-power. They will be of the Parsons type in three groups, while the water-tube boilers will be of the Blechynden type in twelve compartments. There will be four funnels amidships, so placed as to offer the least possible resistance to the wind. The ship will have four screws.—*Army and Navy Gazette.*

Die Zeit learns from Rome that the Italian Admiralty contemplates the construction of four super-Dreadnoughts of 24,000 tons each as soon as the slips of the four Dreadnoughts which are now building become free. The construction of the Italian vessels which are now on the slips will be pushed forward so that the first division will be finished by 1913 at the latest.

According to *Le Yacht* the scouts *Marsala* and *Nino Bixio* have the following characteristics: Displacement, 3455 tons; length over all, 140.3 inches, and between perpendiculars 131.4 inches; beam, 13 inches; draft, 4.05 inches; armament, six 4.7-inch and some 3-inch guns; three torpedo-tubes; Curtis turbines; 14 Blechynden boilers; three screws; 22,500 horse-power; 29 knots speed.

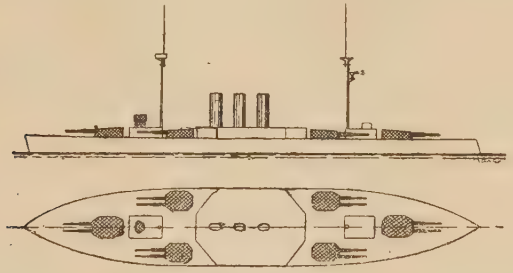
NAVAL MANEUVERS.—The Italian naval maneuvers have this year led to a great deal of discussion in the national press and in Austrian journals. The *Popolo Romano* says that they have been too much advertised. There was to be a disembarkation on the Adriatic coast—800 men, it is said, representing 30,000, and it was announced that the theme was to represent the circumstances which would arise during the first few days of war. To the "A" or national side (Rear-Admiral Amero d'Asti Stella) were assigned the Ionian and Adriatic coasts, and at the opening of hostilities the "A" forces were not concentrated. The enemy, "B" (Vice-Admiral Orestis di Castelnuovo), to whom no coast was assigned, was at the outbreak in the vicinity of the point he intended to attack, which was about 40 miles from Ancona, with all his forces concentrated, and it was the object of "A," when the "B" troops were landed, to break the sea communications. It was, of course, supposed that this scheme represented either the disembarkation of Austrian troops on the Italian coast, or of Italian troops on the coast of Austria. In either case it represented hostilities between the two countries, or was generally regarded as doing so. Such was the character of the weather on the day intended for the disembarkation that it could not take place, and Admiral Bettòlo ordered another set of operations, including the bombardment of Ancona. It has, however, been stated that the real cause of the change of programme was political intervention, but on this point nothing is known. The *Popolo* says that the failure was solely due to the Adriatic maintaining the reputation which it had as the *Turbidus Adria* in Horace's time. It is also stated that the tactical part of the operations included an endeavor to test the respective value of the new classes of ships opposed to one another in varying numbers.—*Army and Navy Gazette.*

JAPAN.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Satsuma	19,200	Yokosuka.	Under trial.
Aki	19,800	Kure.	" "
Kawachi	20,800	Yokosuka.	Launched Oct. 15, 1910
Settsu	20,800	Kure.	Building.
Armored Cruisers.			
Kurama	14,600	Yokosuka.	Launched Oct. 21, 1907.
Protected Cruisers.			
Shikuma	5,000	Sasebo.	Building.
Yahagi	5,000	Nagasaki.	"
Hirado	5,000	Kobe.	"

The battleship *Kawachi,* 20,850 tons, was launched at Yokosuka on October 15. The Emperor attended the ceremony.



"KAWACHI."

The *Kawachi* is the first real Japanese Dreadnought. She was commenced at the Imperial Dockyard of Yokosuka in January, 1909. When completed she will displace 20,850 tons. For armament she will carry twelve 12-inch, ten 6-inch, and twelve 4.7-inch guns, with five torpedo-tubes. The main armor belt is 9 inches thick, and the designed speed 20 knots. A sister ship, the *Settsu,* will be launched at Kure in March next.—*Naval and Military Record.*

The distribution of expenditure in 1911 will include £14,000 for an extension of the third series in the programme, £1,132,000 for new ships to replace others, and a supplementary sum of about £1,100,000. The government is said to be unwilling to enter on a new programme, but money is to be provided for expediting the ships now under construction. These are the *Kawachi* and *Aki,* both at Kure, the latter completing; the *Settsu* and the armored cruiser *Kurama* at Yokohama; the 5000-ton cruiser *Shikuma* at Sasebo; a sister vessel at the Mitsubishi docks, and a couple of big destroyers. The new estimates will, it is said, enable three battleships and one or two large cruisers to be begun, as vessels to replace others which are becoming obsolete, but no great sums will be assigned to these ships individually, and they cannot be actually laid down until the *Settsu* has been launched, and the *Kawachi* (May, 1911). If the third ship is put in hand it will be built in a private yard. It is announced that the harbor at Port Arthur is being dredged, and that a canal is to be constructed which will enable the largest vessels to get alongside the quays served by the railway. All attempts at salving the cruiser *Matsushima,* which sank in the Formosan harbor of Bako, have been abandoned. She lies 8 or 9 fathoms deep, and as much as is possible

will be removed from the hull. The destroyer *Ikadzuchi,* which was cut in two by a schooner at Hakodate last December, has been raised in two parts and is being rebuilt.—*Army and Navy Gazette.*

The torpedo-boat destroyers of the *Umikase* type have the following characteristics: Displacement, 1170 tons (some reports say 1050); speed, 33 knots; Parsons turbines of 21,000 horse-power; two 4-inch and five 3-inch guns; three torpedo-tubes; three stacks. The *Umikase* was launched in 1909 from the Mitsubishi Works at Nagasaki; the *Yamakase* is soon to be launched from the same works; the *Kaifu,* the third of the type, is being built at the Imperial Arsenal at Maizuru.—*Le Yacht.*

RUSSIA.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Emperor Paul I	16,900	St. Petersburg.	Under trial.
Andrei Pervozvannui	16,900	"	" "
Evstafi	12,500	Nicolaiev.	" "
Sevastopol	23,000	St. Petersburg (Baltic Wks.).	Building.
Petropavlovsk	23,000	" "	"
Poltava	23,000	" (Admiralty Yd.).	"
Gangoot	23,000	" " "	"
Armored Cruisers.			
Bayan	7,800	St. Petersburg.	Under trial.
Pallada	7,800	"	" "
Protected Cruiser.			
Outchakoff	6,750	Sevastopol.	Building.

The Russian Marine estimates for the coming year, which have been sent down to the Duma, provide, says the St. Petersburg correspondent of *The Morning Post,* for an ordinary expenditure of 112,994,000 roubles (about £11,300,000), or 23,746,000 roubles more than last year. There is an increase of 16,706,000 roubles on shipbuilding, of 2,755,000 roubles on rearmament, of 2,174,000 roubles for navigation, of 1,448,000 roubles for repairs and the maintenance of ports, and 402,000 roubles for the upkeep of crews. A grant of 3,026,000 roubles is asked for the equipment of the Admiralty shipbuilding yards, and 90,000 roubles for secret expenditure. The estimate for the construction of new battleships is 28,000,000 roubles, as against last year's estimate of 9,507,000 roubles.

During 1911 the battleships *Andrei Pervozvannui, Imperator Pavel I,* and *Yevstafy* (*Eustaphius*) and the armored cruisers *Pallada* and *Bayan,* will be placed in commission, while the cruisers *Asia, Admiral Korniloff* and *Grozyaschy,* and the gunboats *Ardagam* and *Kars* will be withdrawn from the active fleet.—*Naval and Military Record.*

SPAIN.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
España	15,400	Ferrol.	Building.
Alfonzo XIII	15,400	"	"
Jaime I	15,400	"	Ordered.

Good progress is being made with the *España* and *Alfonso XIII,* now under construction at Ferrol, and as soon as the former vessel is launched the *Jaime I* will be laid down. Each of these ships will have a speed of 19 knots and a displacement of 15,450 tons. The large dry-dock is also

shaping well, and it is anticipated that it will be completed in about a year's time. The presence of several hundred British workmen in Ferrol, and the activities of four firms, Messrs. Vickers, Sons, & Maxim, Sir W. G. Armstrong, Whitworth & Co., John Brown & Co., and Sir John Jackson, have created a scene of activity in the place, almost amounting to a transformation.—*Page's Weekly.*

TURKEY.

The Turkish Government has purchased from Germany two old battleships of 9900 tons displacement, the *Weissenburg* and the *Kurfürst Friedrich Wilhelm.*

Arrangements have been completed between the Admiralty and the Turkish Government for a number of officers of the Ottoman Navy to be received in British naval establishments and ships for the purpose of professional training. Since Sir Douglas Gamble relinquished the position of naval adviser and was succeeded by Rear-Admiral Hugh P. Williams, little has been heard of the work done by the British naval delegation. In addition to the Rear-Admiral, the officers lent to the Turkish Government include Lieut. Algernon P. le C. Faught, Lieut. Alban L. Gwynne, Lieut. F. L. Tottenham, Engineer-Commander Louis R. Croisdale and Assistant-Paymaster Richard F. Durman. Lieut. Faught has just arrived in England with six naval officers, and nineteen others will shortly follow. This seems to indicate that the new government is really desirous of doing something to re-establish the naval power of Turkey.—*Naval and Military Record.*

UNITED STATES.

VESSELS BUILDING.

No.	Name. *Battleships.*	Speed. Knots.	Where Building.	% of Completion Sept. 1.	Oct. 1.	Nov. 1.
30	Florida.....	20¾	Navy Yard, New York.	74.2	77.4	80.6
31	Utah	20¾	New York Shipbl'g Co.	85.5	88.0	89.9
32	Wyoming.....	20½	Wm. Cramp & Sons.	35.5	38.9	43.3
33	Arkansas	20½	N. Y. Shipbuilding Co.	43.9	47.8	50.1

NEW "PLOTTING" POSITION.—The United States Navy Department has decided to instal an experimental compartment on board some of the battleships in connection with the fire-control system. This will be a station below the deck, to be called a "plotting-room," and to be used as a sort of clearing house or "central" for all the messages transmitted in connection with the range-finding operations under control of fire. In this connection further investigation is being made by the naval authorities respecting the most effective and approved method of transmitting messages. At present most of the ships use three systems in one or another way—the voice-tube, the electrical transmitter and the telephone. Opinion appears to be largely in favor of the mechanically operated device, because it is the simplest in many respects. Reports from some of the ships are in favor of the telephone, which, however, presents some difficulties of communication. The voice-tube has been a subject of considerable scientific experimentation at the Boston Navy Yard as on board ship. The system has its defects, but it is manifestly preferable to other methods under certain local conditions. The system of fire-control is being improved constantly, in accordance with the expectations derived from the experience of observers during target practice.—*Naval and Military Record.*

GOVERNMENT CONTROL OF WIRELESS.—In his annual report to the Secretary of War, Brig.-Gen. James Allen, chief signal officer of the United States Army, takes issue with the operating commercial wireless telegraph

companies that claim to have efficient interference preventers, and, deploring the confusion which he states exists everywhere in the transmission of government messages, urges that measures be taken at once to secure government control of wireless telegraphy, both in peace and war.

Referring to the Berlin international agreement of 1906 he says: "As the United States up to this time has not given its adherence to the convention, ships flying the American flag find themselves without standing in international wireless telegraph circles, as none of the contracting countries are compelled to receive a telegram from a vessel of a non-contracting nation, and any coastal station in a foreign country may refuse to transmit a message to a station on shipboard which is subject to a non-contracting nation.

"The history of the whole matter is recorded in a published copy of the treaty (Government Printing Office, 1907) issued by the Bureau of Equipment, Navy Department; in the report of the United States ambassador to Germany, 1906, and in Senate Document No. 452. The only action of the United States Government looking to the regulation of wireless telegraphy is the approval of the President, July 29, 1904, of the report of an inter-departmental board convened to investigate the entire question of wireless telegraphy in the service of the national government.

"Owing to the absence of definite regulations there is great confusion in the transmission of wireless messages on the coast of the United States, which interferes very materially with wireless communication between the various sea-coast defences and with our ships at sea. The army now has 15 wireless stations on shore, located at various points in the United States and Alaska."—*Electrical World.*

BRIDGE-CONTROL FOR TURBINES.—The collier *Neptune* will have a unique system of electro-pneumatic control, by which the vessel in case of emergency can be maneuvered from the bridge or from any one of several other control stations. The system will be an application of the electro-pneumatic mechanism which has been used successfully in operating railroad switches and signals. While the machinery, under ordinary conditions, may be managed by the engineer officer in accordance with instructions conveyed by the ship's telegraph, it will be possible to control the movements of the vessel entirely from the bridge by means of the electro-pneumatic operating gear, which works the throttle valve; thus in emergencies or when it is otherwise necessary, the engines can be manipulated from the bridge. In case the steering gear becomes disabled, steering with the screws could be done with precision by direct control from the bridge. Another feature of the electro-pneumatic control system is an automatic signal indicating exactly what the engines are doing. In case of failure of the electro-pneumatic control the ordinary system of telegraph or bell signals can be resorted to, as usual, the installation of the electro-pneumatic control being intended as a duplicate system, rather than as a substitute for the ordinary control mechanism.

This system of engine control is only one of the unique features of the new collier, for she is to be fitted with the Westinghouse marine steam turbine in connection with the Melville-Macalpine reduction gear. The Department has been assured against loss, in case the machinery proves unsatisfactory.—*The Navy.*

ORDNANCE AND GUNNERY. TORPEDOES.

CINEMATOGRAPH RECORD OF COLLECTIVE BROADSIDES.—*The Hampshire Telegraph* gives details of battle practice as carried out by the Dreadnought battleships of the Home fleet in the Channel under the most realistic conditions. Instead of individual practice the Dreadnoughts advanced as a combined squadron steaming at 16 knots, and fired at a target 90 feet

long and 30 feet high, towed by the cruiser *Indomitable*. On reaching the firing area the whole of the Dreadnoughts, still steaming line ahead at the same speed, opened fire with full broadsides of 12-inch guns, the target being 5 miles distant. The firing was good as soon as the range had been found, and after 3 minutes not a vestige of the target remained. A new target was requisitioned, and the battleships *Lord Nelson* and *Agamemnon* took up the firing at shorter range with three-quarter charges behind 12-inch projectiles and made good practice. A third run was made, all the ships firing at battle-practice ranges, but with reduced charges.

Another report says: The firing squadron was headed by the *Dreadnought*, and included the *Superb*, *Lord Nelson* and *Agamemnon*, steaming at 16 knots. The vessels opened fire simultaneously on arriving within a distance of about 5 miles from the *Indomitable*. The din was terrific, and the water near the target rose in a series of waterspouts, rendering the target itself invisible except at intervals. Nevertheless, hardly a vestige of it remained 3 minutes later, so accurate was the aim of the gun-layers at an object also in motion. Other warships carried out this new form of battle practice under varying conditions, with similar success.

Squadron firing under these conditions has an added interest by the fact that the Admiralty official photographer was on board the towing cruiser *Indomitable* taking cinematograph records of the shots as they fell.—*Naval and Military Record.*

La Vie Maritime gives the following tables showing the results of the French battle practice held last August, using the coast-defence ship *Fulminant* as a target. The target was stationary; the range about 7000 meters; each ship made one run past, following a leader, and firing for 6 minutes with main-battery guns only. The second squadron fired first, and it was necessary to mount wire-screen targets on the wreck when the first squadron fired:

SECOND SQUADRON.

Battleships.

	Shots	Hits	% of hits	Efficiency
1. Jauréguiberry	95	30	30.6	33.4
2. Bouvet	149	30	20.8	22.6
3. Carnot	92	17	18.4	21.8
4. Saint-Louis	175	25	14.3	12.3
5. Charlemagne	189	25	13.2	11.2
6. Gaulois	190	14	7.4	7.5

Cruisers.

1. Dupetit-Thouars	110	37	33.6	24.3
2. Marseillaise	113	32	28.3	22.4
3. Condé	133	34	29.5	20.8
4. Gloire	136	18	13.2	10.2

FIRST SQUADRON.

	Hits	% Efficiency
1. Justice	20	26.7
2. Démocratie	17	22.9
3. Ernest-Renan	22	16.6
4. Patrie	26	15.1
5. Jules-Michelet	17	11.7
6. Vérité	10	11.1
7. Jules-Ferry	20	10.9
8. Liberté	7	10.4
9. République	19	10
10. Victor-Hugo	14	7.8

CENTER-LINE VS. ECHELONED TURRETS.—The relative value of the *Orion* and *Neptune* systems of mounting 10 big guns is by no means an uninteresting or unprofitable matter for discussion. It is, of course, impossible to go into it fully without exact details as to the heights of the turrets and their angles of fire, and these have not been disclosed. A somewhat similar position, however, exists between the United States *Wyoming* and the Argentine *Moreno*. Each of these ships is to carry twelve 12-inch in six turrets; but, whereas the *Wyoming* will have the whole of her turrets on the center-line, the *Moreno* will have only four so placed, the other two being en echelon. The result is that the Wyoming will be able to fire four guns ahead and six astern, while the *Moreno* will fire eight fore and aft. On the broadside both ships will bring 12 guns to bear, but the differences in arrangement necessarily lead to differences in the respective arcs of fire. For the various turrets these are as follows:

Arc Covered on Each Beam.

	Wyoming.	Moreno.
Turret No. 1.....	150 deg.	150 deg.
Turret No. 2.....	135 deg.	135 deg.
Turret No. 3.....	140 deg.	180 deg. starboard. 100 deg. port.
Turret No. 4.....	135 deg.	180 deg. port. 100 deg. starboard.
Turret No. 5.....	165 deg.	135 deg.
Turret No. 6.....	150 deg.	150 deg.

When these angles are worked out it is found that the arc through which the *Wyoming* can bring the whole of her heavy guns to bear is one of 95 degrees, while in the case of the *Moreno* it is 10 degrees less. Again, the *Wyoming* can sweep 120 degrees with 10 guns, while the *Moreno* can do so only over 105 degrees. With eight guns the North American ship can cover 135 degrees and the South American 120 degrees. The differences in the case of the *Neptune* and *Orion* are probably quite as great; but it is, of course, impossible to compare them until full details are to hand.—*Naval and Military Record.*

CORDITE. *Its Chemistry and Manufacture.*—The production of a smokeless powder was ever the dream of the military strategist, and with the discovery of gun-cotton the conclusion was hastily arrived at that the ideal propellant was found, only to be rudely dissipated by numerous serious disasters. Gun-cotton for many years resisted all attempts to render its combustion sufficiently under control for it to be adopted as a propellant, yet to-day it is the basis of the smokeless powders of all nations. Its early failures were entirely due to the retention in the nitrated cotton of the physical characters of the parent cotton, for even after reduction to an extremely fine state of division during the process of manufacture, the fibrous nature of the cotton persisted. Success has only been attained by the destruction of this fiber, and the smokeless powders of all nations may be classed either as simple gelatinized gun-cottons in which soluble nitrocelluloses have been gelatinized by treatment with an ether-alcohol mixture, or as nitrocellulose-nitroglycerine colloids, in which the nitrocellulose employed may be of the soluble variety, as in ballistite, or the insoluble (true gun-cotton), as in the case of cordite.

The introduction of blasting gelatin by Nobel (1875) consisting of some 90 per cent nitroglycerine with 10 per cent of soluble nitrated cotton in a gelatinized form, was the first step toward the production of powders of the cordite type. The high percentage of nitroglycerine rendered blasting gelatin unsuitable for use in guns, but by incorporating the two constituents in equal quantities, Nobel gave to the world the first successful smokeless powder of this class, ballistite. Cordite was the outcome of the

work of a committee presided over by the late Sir Frederick Abel, and was patented a year later than ballistite, in 1889. The essential difference between ballistite and cordite is that while the former contains soluble nitrocelluloses, cordite contains the insoluble or tri-nitrocellulose. This change in the character of the nitrocellulose employed entailed the introduction of acetone in the manufacture of cordite. Soluble nitrocotton and nitroglycerine can be thoroughly incorporated under proper conditions in the presence of water without the aid of any solvent, but the ingredients of cordite can only become perfectly incorporated in the presence of a mutual solvent. It is essential that the solvent shall be sufficiently volatile to permit of its removal at reasonably low temperatures from the finished powder, and acetone, which boils at 56° C. (132.8° F.), fulfills all the conditions best.

It is important to note that nitroglycerine is the only explosive containing an excess of oxygen, all nitrocelluloses being theoretically deficient in this element to give complete combustion of carbon to carbon dioxide and hydrogen to water. There are therefore admirable theoretical grounds for the incorporation of these two explosives with each other. The total change in physical characters of both nitroglycerine and nitrocellulose brought about entirely alters the character of their explosion; singly, both constituents are beyond control once combustion is started; gelatinized together, combustion is regularly progressive throughout the mass, an essential condition for a propellant.

The earlier forms of cordite consisted of nitroglycerine, 58 per cent; nitrocellulose, 37 per cent; vaseline, 5 per cent. It was soon found that serious erosion took place in the guns, and Sir Andrew Noble showed this to be due to the rapid motion of the gaseous products at very high temperature. Since the temperature is a function of the nitroglycerine content, combustion to carbon dioxide taking place to greater extent with its accompanying higher calorific intensity, it followed that reduction of the nitroglycerine would lower the temperature of the products and lessen the erosion. This led to the introduction of modified (M. D.) cordite of the following composition: Nitroglycerine, 30 per cent; nitrocellulose, 65 per cent; vaseline, 5 per cent—practically a reversal of the former proportions of the chief ingredients. The introduction of the vaseline was made to overcome metallic fouling in the gun, arising from surfaces of metal in practically a clean condition rubbing against each other as the projectile moved outward. The vaseline decomposition products provided just the slight lubrication needed. It has performed another important office, little thought of on its introduction, in acting as a "stabilizer" in the cordite.

In the manufacture of cordite, the gun-cotton employed is thoroughly dried at a temperature of 40° C. (104° F.), and is then mixed by hand with the proper proportion of nitroglycerine, the mixture being finally passed through a sieve. The "paste" obtained is transferred to an incorporating machine of an exactly similar type to that employed in a machine bakery, except that temperature contol is arranged for, and there worked into a thorough dough with the requisite quantity of acetone. The first kneading occupies about 3½ hours; then the vaseline is added and a further kneading for a similar period takes place. "Cordite dough," in which every trace of the fibrous character of the gun-cotton has disappeared, results, and this dough is then shaped into the finished threads, cords or rods by pressure through suitable dies. As the thinner makes pass from the press they are wound on drums, thicker qualities being cut into suitable lengths as they pass out on an endless band. The acetone remaining must now be removed by drying in suitable rooms at a temperature of 43.3° C. (110° F.). The removal of solvent from the larger sizes of all smokeless powders offers considerable difficulty owing to their horny nature; the odor of acetone is readily detected in freshly ground cordite after long storage.

Naturally the detection of products which may indicate decomposition

actually occurring or likely to occur is important, and for this purpose Abel's heat test, first introduced for gun-cotton about 1875, is employed for cordite. The test depends on the liberation of iodine from potassium iodide by the action of nitrogen peroxide, the principal decomposition gas. The ground explosive is heated to 82° C. (180° F.) in a tube, and the time noted for discoloration of the test paper to a certain standard tint. The question at once suggests itself, Does the test show decomposition products which were present in the explosive, or have they resulted from heating during the test, or both conditions acting together? Very divergent opinions are held as to the value of the Abel test as an indication of the stability or "life" of gelatinized explosives. Certainly a powder giving a bad test must be regarded with suspicion, but it is obviously not an easy matter to fix a time limit for a test which is subject to adverse criticism.

One of the most important considerations with any explosive is its stability. The question naturally arises, Is the molecular arrangement in such substances as nitrocellulose and nitroglycerine stable under ordinary conditions of temperature? Their explosive properties depend entirely on molecular rearrangement, which is practically instantaneous when detonation occurs. Certainly slow decomposition occurs in most nitrocompounds of the explosive class at temperatures not greatly above the normal, with the production of oxides of nitrogen, and it has been shown that these oxides act catalytically on the explosive; in other words, their effect becomes cumulative and may lead to ignition. In order to avoid this catalytic action, "stabilizers" have been introduced in many explosives, substances capable of absorbing these nitrogen compounds. As already mentioned, the vaseline in cordite appears to perform this useful function.—*Nature.*

NAVAL GUNS. *A Summary of Progress.*—The 13.5-inch gun now seems to be definitely rehabilitated as a naval weapon. The old 13.5-inch had a very brief existence. It was put first in the *Rodney, Howe, Anson* and *Camperdown,* later in the *Nile* and *Trafalgar,* and lastly in the *Royal Sovereign* class, after which it was replaced by the 12-inch. If the new 13.5-inch is replaced at all it seems far more likely that it will be by a larger than by a smaller gun, for 14-inch weapons are being freely spoken of in Germany and the United States, and are to be mounted in the Brazilian *Rio de Janeiro.*

The history of the naval gun goes back nearly 600 hundred years. James, in his *Naval History,* says that artillery was used as early as the thirteenth century in a naval engagement between the King of Tunis and the Moorish King of Seville. One John Barbour mentions "Crakys of War," otherwise guns, as having been used by Edward III in his Scottish campaign of 1327, and there is no doubt that guns were in use at and a little before this date. It was in 1338, however, that guns first figured in the stores of English ships of war, iron cannon with chambers (or breech-pieces), brass cannon and hand guns being detailed for the *Christopher of the Tower, Mary of the Tower* and *Bernard of the Tower.* Laird Clowes' *Naval History* gives the following description of these primitive weapons: The guns with chambers, which were amongst the earliest guns used on board ship, were in reality breechloaders. They were, for the most part, small. In them the after portion of the upper part of the gun was cut away in such a manner that the loaded "chamber" could be dropped into the bore.

The *Henri Grâce à Dieu,* built in 1514, carried the following guns as her heavy armament: Four cannon, three demi-cannon, four culverins, two demi-culverins, four sakers, two cannon petros and two falcons. Guns under the same denomination were in existence at the time of the Armada, and as the changes in the intervening 70 years were probably small the following details of the later guns will serve to give an idea of the artillery power of the *Henri Grâce à Dieu:*

	Caliber, inches.	Weight of gun, lbs.	Weight of shot, lbs.	Random range, paces.
Cannon	8	6000	60	2000
Demi-cannon	6.5	4000	30.25	1700
Culverin	5.5	4500	17.3	2500
Demi-culverin	4.5	3400	9.3	2400
Demi-saker	3.5	1400	5.3	1700
Cannon petro	6	3000	24.25	1600
Falcon	2.5	800	3	1500

The minor guns carried in the ships were fourteen "port pieces," two "demi-slings," eight "fowlers," sixty "bassils," two "top pieces," forty "hail-shot pieces," and a hundred hand guns. In addition, however, proving that guns had not yet entirely displaced the older weapons of naval war, the ship was also provided with 500 bows of yew, 10 gross of bow-strings, 200 morris spikes, 200 bills and 10 dozen lime pots; the last, probably to be emptied into the air when the ship had got to windward of her enemy, for the blinding of her opponent's crew.

The *Sovereign of the Seas*, built in 1637, affords an illustration of the changes brought about in 100 years. Her armament was made up as follows:

	Length, feet.	Weight, cwt.
Lower Deck—		
Broadside, 20 cannon-drakes	9	45
Stern Chasers, 4 demi-drakes	12.5	53
Bow Chasers, 2 demi-drakes	11.5	48
Luffs, 2 demi-drakes	10	44
Middle Deck—		
Broadside, 24 culverin-drakes	8.5	28
Stern Chasers, 4 culverins	11.5	48
Bow Chasers, 2 culverins	11.5	48
Main Deck—		
Broadside, 24 demi-culverin-drakes	8.5	18
Stern Chasers, 2 demi-culverins	10	30
Bow Chasers, 2 demi-culverins	10	30
Upper Deck—		
Forecastle, 8 demi-culverin-drakes	9	20
Half-deck, 6 demi-culverin-drakes	9	20
Quarter-deck, 2 culverin-drakes	5.5	8
Forecastle, pointing aft, 2 culverin-drakes	5.5	11

The suffix "drake" indicated that the gun was capable of being fired with heavy charges. The cost of guns at this time was from £12 to £15 per ton. By 1677 there had, of course, been considerable changes in naval architecture; nevertheless, the old names still remained for the guns, and did not finally disappear until the end of the century. In the year mentioned it was decided to build thirty new ships, one first-rate, nine seconds and ten thirds. Their armament, with the number of men allowed for the working of each gun, was as follows:

	1st rate.	2nd rate.	3rd rate.	Men per gun.
Cannon (42-pounders)	26	—	—	8
Demi-cannon (32-pounders)	—	26	26	6
Culverin (18-pounders)	28	26	—	5
12-pounders	—	—	26	4
Sakers	44	36	14	3
3-pounders	2	2	4	2
	—	—	—	
	100	90	70	

From the beginning of the eighteenth century guns were designated by the weight of the shot they fired. In the days of rifled muzzle-loading guns the weight of the gun was always used, occasionally in conjunction with the caliber. Breech-loading guns, too, were at first differentiated by their weight, but now the caliber is universally used. It is interesting, by the way, to note that in 1653 prize money was reckoned at the rate of 10 shillings per ton, and an additional £6 3s. 4d. for each gun captured, while £10 was the award for each gun in ships destroyed.

In 1779 the carronade was invented by General Robert Melville, and soon became a great favorite in naval armaments. The first ship equipped with the new weapon was the *Rainbow,* 44, and the result of the change may be seen in the following comparison:

Original Armament.	Broadside.	As re-armed, 1782.	Broadside.
20 18-prs. 22 12-prs. 2 6-prs.	318 lbs.	20 68-prs. 22 42-prs. 6 32-prs.	1238 lbs.

From now until the invention—or, rather, the restoration—of rifling, there were few changes. The *Victory* was built with thirty 32-pounders, thirty 24-pounders, thirty-two long and twelve short 12-pounders. At Trafalgar she carried two 68-pounders, thirty-two 32-pounders, thirty 24-pounders and thirty-two 12-pounders. The first heavy rifled guns were made in 1865. The following table will show the progress made in the early days of the new gun:

First made in	Caliber.	Weight.	Shell.
1865	7-in.	6½-ton	115-lb.
1868	10-in.	18- ton	410-lb.
1870	12-in.	25- ton	614-lb.
1871	12-in.	35- ton	820-lb.
1874	12.5-in.	38- ton	820-lb.

In 1875 a 14.5-inch gun was made, weighing 80 tons. After several experiments the bore was turned to 15 inches, and subsequently to 16 inches, the weight of the shell being 1700 pounds. Four of these guns were mounted in the old *Inflexible.* It was in 1880 that, after having once been tried and abandoned, breech-loading ordnance was finally adopted for naval purposes, the first ship to have breech-loaders in turrets being the *Conqueror,* launched at Chatham in 1881. Vast improvements have been made since then—how vast we cannot judge until the details of the new 13.5-inch guns have been made known. The largest guns ever mounted in British ships were the 16.25-inch 110½-ton guns of the *Sans Pareil, Victoria* and *Benbow,* firing a shell of 1800 pounds, with an initial velocity of 1987 foot-seconds. Denmark has had a 13.98-inch gun, but of only 51 tons, firing a shell of 1157 pounds at 1762 foot-seconds. France had 16.5-inch 75-ton guns, firing a 1433-pound shell, in the old battleships *Caiman, Indomptable,* *Requin* and *Terrible;* 14.5-inch 75-ton guns, firing a 1235-pound shell, were mounted in the *Formidable* and *Admiral Baudin,* while 13.3-inch guns are now mounted in the *Jemmapes, Valmy, Marceau, Hoche* and *Brennus.* The largest gun ever mounted was probably the 17.72-inch with which the Italian *Dandolo* and *Duilio* were equipped in 1876-1878, these weapons weighing 100 tons and firing a 2000-pound shell. A shell of the same weight was fired by the 17-inch gun mounted in the *Andrea Doria, Francesco Morosini, Italia, Lepanto, Re Umberto, Ruggiero de Lauria, Sicilia* and *Sardinia.* It does not seem in the least unlikely that we shall soon have overtaken these calibers with new guns. It is only a step from the 13.5-inch to the 16.25-inch, and engineers would find little difficulty in going beyond this if naval architects can give them sufficient space and structural strength.—*Naval and Military Record.*

BALLOON GUNS AND PROJECTILES.—The subject is receiving so much attention just now that we think that our readers will be interested to hear what is being done in Germany in the way of ordnance for attacking balloons and airships generally. We will deal first of all with the guns. These guns have small bores, and use light projectiles, so that they can be fired quickly. The barrels are comparatively long, so that a high initial velocity and a low trajectory is obtained. Telescope sights and a range-finder are provided. The latter is fitted with an arrangement which gives the necessary elevation as the distance is read off.

The ordinary field-gun has a 6.5-cm. bore, and is fitted with hydraulic brake and spring recoil. A coiled spring is provided to balance the weight of the gun as the latter is pointed above the horizontal. The upper part of the gun-carriage is movable, and the wheels can also be given a half-turn away from the body, which gives considerable facilities for quick aiming. This equipment weighs 875 kilos., 352 kilos. of this being in the gun, 523 kilos. in the carriage. The projectile weighs 4 kilos.—about 8 pounds 13 ounces. The initial velocity is given as being 620 m.—say, 2034 feet a second; the extreme range, 8650 m.—9450 yards; and the height of fire obtainable, 5700 m.—say, 18,700 feet. The gun can be elevated through an angle of 70 degrees above the horizontal, and depressed 5 degrees below it, and it can be revolved right round through an angle of 360 degrees.

A heavier type of field-gun has a bore of 7.5 cm., and weighs when ready for firing 1065 kilos.—2447 pounds—of which the carriage represents 615 kilos. The weight of the projectile is 5.5 kilos.—say 12 pounds 2 ounces. The initial velocity is stated to be 625 m. per second, and 9100 m. and 6300 m. are given as the extreme range and height attained at trials. The motor car is designed for an average speed of 45 kiloms. per hour, and weighs 3250 kilos.—7163 pounds—without the gun. It carries 62 projectiles under the seats, and is propelled by a 50-horse-power motor. It is steadied during firing by a special arrangement which presses the platform against the axles. The gun can be elevated to an angle of 75 degrees from the horizontal, and can be revolved through a complete circle.

A 10.5-cm. naval gun is also made by Krupps. It weighs 3000 kilos. when ready for firing, the projectile 18 kilos., the gun 1400, the carriage 1600. Its initial velocity is 700 m. per second, and 13,500 m. and 11,400 m. are given as the extreme range and height attainable. It can, as in the case of the 7.5-cm. gun, be elevated through an angle of 75 degrees from the horizontal, and revolved through a complete circle. All these three guns are 35 calibers long.

The guns made by the Düsseldorf firm are of a somewhat different construction. The bore is 5-cm. and the barrel is 30 calibers long. The gun is worked from a center-piece by a hand-wheel and weighs 140 kilos.—400 kilos. with shield. It can be elevated to an angle of 70 degrees above the horizontal, and depressed 5 degrees below it, and can be revolved through a complete circle. The total weight of the gun, ammunition, five men and car comes to 3200 kilos. The car is built at the factory of Geheime Baurat Ehrhardt, at Zella, and is driven by a benzine motor of 50 to 60 horse-power, which propels it at a normal speed of 45 kiloms. per hour, and is said to be capable of negotiating gradients of 22 per cent even on bad roads. The whole, including the wheels, can be protected by nickel-steel-plate shields.

The question of ammunition most suitable for balloon guns is also receiving attention in Germany, and this same Düsseldorf firm has recently introduced a combined shrapnel and ordinary shell for use primarily with this type of weapon, but which is also intended for field and naval guns.

The principal difference between the ordinary shrapnel grenade and the Brizanz shrapnel—Fig. 9—is that while in the first, after the fuse is set, both parts of the shrapnel grenade explode in the air, in the case of the

Brizanz shrapnel, after the explosion of the shrapnel part, the shell part is carried on to the target, or to the ground, where it detonates, giving off in its flight an observable cloud of smoke, as shown in the accompanying engraving—Fig. 8.

The combined projectile is contained in two thin steel cases, a little more than two-thirds of the lower part containing the shrapnel, and the

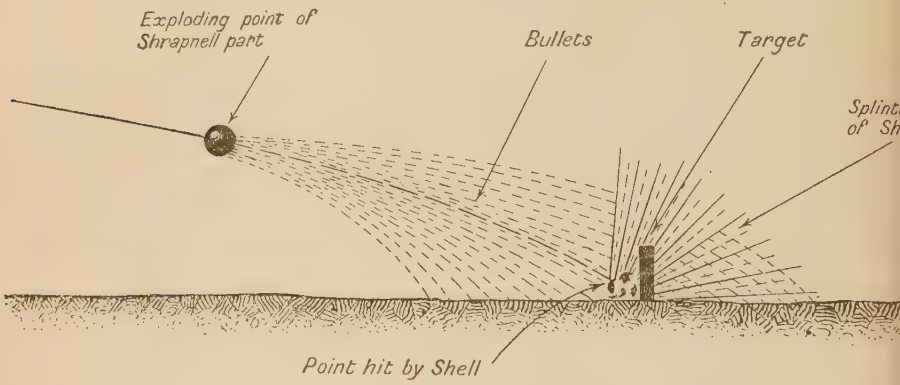


FIG. 8.—SHOWING EXPLOSION OF A BRIZANZ SHELL.

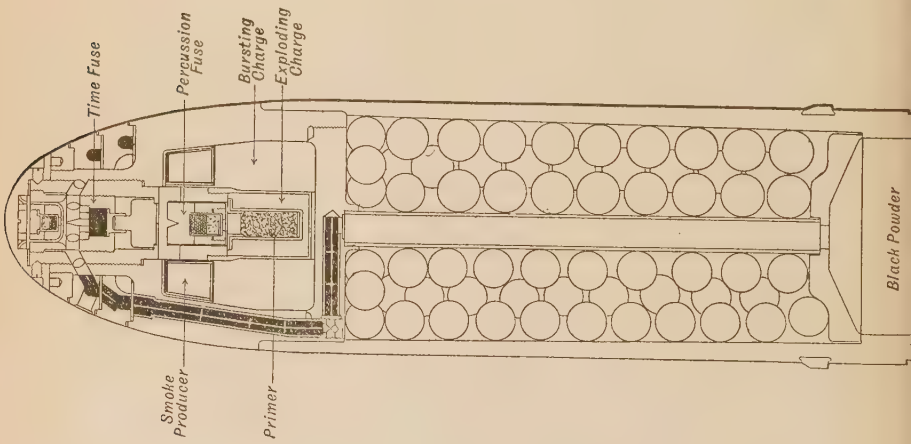


FIG. 9.—BRIZANZ SHRAPNEL.

upper part serving as a common shell. By means of a double fuse, it can be set either to explode both pieces at the same time directly above the object aimed at, or to explode the shrapnel part only, sending the shell part ahead.

The shell part for a 7.5-cm. gun contains about 100 grains of picrine and some fulminating mercury behind the fuse. It weighs 1.5 kilos. and breaks into 60 parts. The Brizanz shrapnel for a 10.5-cm. bore carries a shell part weighing 2.78 kilos, with 180 grammes of explosive matter, including the smoke charge to show the trajectory, besides 586 balls of 11 grammes weight each. The balls in the shrapnel are embedded in tri-

nitrotoluol. The effect of a 7.5-cm. projectile is said to be sufficient to destroy guns and ammunition wagons and to put a whole gun party *hors de combat.*

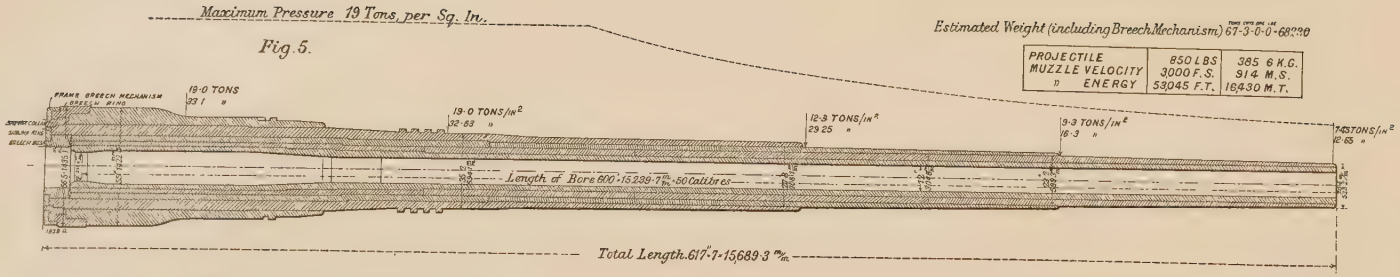
Both shrapnel and shell parts come into play whether the concussion or the time-fuse is used. In the latter case the tri-nitrotoluol burns inside the shrapnel, and by the reason of the gases formed in the bottom chamber the shrapnel part separates and explodes below the highest point of the trajectory in front of and above the target, and sprays grape shot over it. The head or shell follows the trajectory and explodes on reaching the target or the ground. Some of the pieces are provided with teeth to rend the fabric if the shell be used against a balloon. Trials with 7.5-cm. projectiles are said to have given, besides the 300 balls of 9 grammes each, 158 splinters of shell, etc., and from a 7.62-cm. shell with 267 balls of 10.85 grammes each, 103 marks made by pieces of the shell, besides those made by the balls, were counted on the target. Only pieces weighing over 5 grammes were taken into consideration.

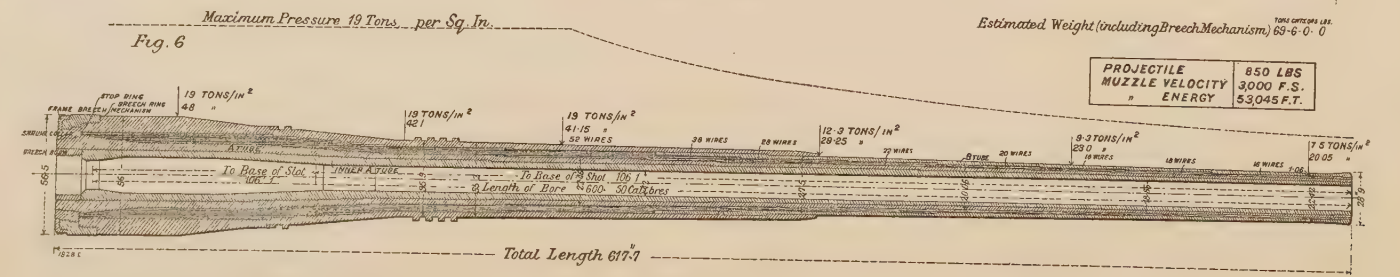
If the whole projectile is used as a shell, both parts explode when reaching the ground or the object aimed at. In this case the tri-nitrotoluol and the picrine explode at the same time with a great noise, and an offensive smell, having considerable demoralizing effect upon those to whom the thing is new and unexpected. The double fuse is made of aluminium, and has three symmetrically arranged wings, which, in consequence of the rotary motion of the projectile swing outwards, and help to tear the balloon fabric. A concussion fuse is furnished to make the shell explode when it hits parts of an airship capable of resistance.—*The Engineer.*

VICKERS' 12-INCH 50-CALIBER GUN.—Among the exhibits at the Japan-British Exhibition are models of 12-inch 50-caliber guns. It is true that these are not the weapons actually made for the British Navy, but they represent the Vickers' practice, and the drawings and illustrations which we reproduce are therefore typical of the armament of the latest battleships of more than one power. Figs. 5 and 6 are sections, respectively, of a solid-steel and wire-wound gun of 50 calibers in length, to give the same ballistics.

The comparative sections will be studied with interest in view of the controversy which is reawakened from time to time as to the advantages and disadvantages of the wire-wound and the solid-steel systems of construction. Now that steel of a thoroughly reliable character is obtainable for guns, there is not the same objection to the use of steel rings shrunk on to reinforce the inner tube instead of wire, especially as the latter is more expensive to manufacture; but while the Vickers Company make both types, the British Navy still prefers the wire-wound gun, probably because it ensures much greater radial strength, and also because any fracture of the inner tube due to excessive stress is not likely to cause disaster.

The all-steel gun (Fig. 5) is built up of parallel tubes shrunk one over the other. The A tube is a stout tube of nearly uniform section from end to end. Over this is shrunk the B tube in four portions, extending the whole length of the gun, the interior of the B tube being a trifle less in diameter than the exterior of the A tube before the tubes are built together. The C tube is next shrunk on in three pieces, which extend nearly to the muzzle. There is again a slight difference in the exterior of the B tube and the interior of the C tube preparatory to shrinking; in this case the difference is somewhat greater than between the A and B tubes. Next comes the D tube, in one piece about half the length of the gun, and it is followed by a short jacket. These two last tubes are shrunk on in the same manner as the B and C tubes, the amount of shrinkage increasing with each successive tube. It will be understood that the amount of this shrinkage is an important factor in a gun constructed on this principle; the manufacture of the gun demands a fine degree of accuracy also in the processes of machining. The breech-bush which carries the breech-screw


Maximum Pressure 19 Tons per Sq. In.
Fig. 5.
Estimated Weight (including Breech Mechanism) 67-3-0-0 68·39
PROJECTILE 850 LBS 385 6 K.G.
MUZZLE VELOCITY 3000 F.S. 914 M.S.
" ENERGY 53045 F.T. 16430 M.T.
19·0 TONS/IN²
19·0 TONS/IN²
12·3 TONS/IN²
9·3 TONS/IN²
7·43 TONS/IN²
Length of Bore 600·15 239·7 m/m 50 Calibres
Total Length 617·7·15689·3 m/m



VICKERS' ORDNANCE AT THE JAPAN-BRITISH EXHIBITION; 12-INCH 50-CALIBER NAVAL GUN.

or plug is screwed into the D^1 tube, and a ring is shrunk over the rear portion of the breech-bush. Over this ring and a part of the D^1 tube is shrunk a collar, which, in combination with the D^1 tube and the breech-ring, withstands the rearward pressure when the gun is fired.

In the case of the wire-wound gun (Fig. 6) there is an inner A tube, whose exterior diameter is decreased towards the muzzle, due to a slight taper and the existence of a number of small shoulders. The interior of the next tube—the A tube—has its inside diameter somewhat less than the exterior diameter of the inner A tube. The outer tube is slightly heated, and the inner A tube is forced into it until the shoulders on the inner tube are brought up against the shoulders on the outer tube. Layers of steel wire are wound on the outer tube at varying degrees of tension, the number of layers increasing from 16 at the muzzle to 80 at the breech end. About 130 miles of wire, having a cross-section of 0.25 by 0.06, and a tensile strength of 100 tons per square inch, are used in the manufacture of this gun. The jacket and the B tube are then put on over the wire. The breech of the gun is closed by a breech-screw or plug, which works in the breech-bush, the breech-bush in its turn being screwed permanently into the A tube. Over that part of the A tube which is not reinforced by the wire is shrunk a collar, which, in combination with the breech-ring, assists the A tube to take up the longitudinal stresses which occur on firing the gun.—*Engineering.*

Experiments designed to test the efficiency of guns of ordinary caliber when directed at an airship flying at an altitude of 4000 feet, and 2 miles from shore, were carried out in Whitland Bay in September by batteries of the Royal Field and Royal Garrison Artillery. A dummy airship, secured by a wire rope, was towed across the bay at 20 knots an hour by the cruiser *Adventure.* The Field Artillery with 18-pounders did very good shooting, but the Garrison Artillery with 12-pounders were not quite so successful.—*Page's Weekly.*

The Moniteur de la Flotte, in an article advocating the use of a very high-speed but short-range torpedo for torpedo-vessels, gives the following particulars of the latest model French torpedo: Speed, 38 knots for 1000 meters, 33 knots for 2000 meters, 28 knots for 3000 meters; extreme range, 4000 meters; deviation at 3000 meters, less than 30 meters; diameter, 45 cm.; charge, 108 kilograms; length and weight unchanged from previous model; cost, 13,500 francs, as against 12,000 francs for previous model.

INTERNAL COMBUSTION ENGINES.

The latest reference to the use of internal combustion engines for marine purposes is to be found in the annual report of *Lloyd's Register* of British and foreign shipping, whose new rules for internal combustion engines appeared in a recent issue. The report states that while the use of these engines for marine purposes has hitherto been confined to small vessels and yachts, the possibility of using them as the motive power of large vessels is now becoming a question of immediate and practical importance. The internal combustion engines in most general use on land, and also those fitted in small vessels are worked upon the 4-stroke cycle principle, and are single-acting, so that with each cylinder there is only one impulse for two revolutions of the shaft. With this type of engine there is considerable difficulty in effecting the reversal of the direction of rotation of the engine, and when these engines are used for marine purposes the astern motion of the screw has usually been obtained by the use of toothed-wheel gearing.

Comparatively recently there has been a development in the Diesel oil engine for marine work. A two-stroke cycle has been successfully adopted, and the reversal is effected in the engine itself, the crank shaft

being directly coupled to the screw shaft. The Diesel oil engine is now being fitted to three fairly large vessels being built on the Continent under the supervision of the surveyors to *Lloyd's Register*. One set is being constructed on the older principle of the four-stroke cycle with single-acting cylinders, and will be of about 450 indicated horse-power. Another set is being made on the two-stroke cycle, also single-acting, and is intended for a twin-screw vessel, the power being about 900 indicated horse-power on each shaft. The third set is being made on the two-stroke cycle double-acting system, each cylinder providing two impulses per revolution; this also will be fitted in a twin-screw vessel, the total power being about 1800 indicated horse-power. In each of these cases the engines will be directly coupled to the screw shafts.

In a set of internal combustion engines, which is being constructed under the Institute of Marine Engineers' survey in this country for a vessel of about 260 tons, there are several novel features. The engines are intended to work with gas produced on board from anthracite coal. The cylinders are of comparatively small size, and the engines are intended to run at a high rate of revolution, and will not be reversible. The connection with the screw shafts will be made by means of a hydrodynamic transformer in which a turbine pump driven by the engine delivers water to another turbine coupled directly to the screw shaft. The arrangement is such that the screw shaft will rotate at a much less rate of speed than the engines, and provision is also made for reversing its direction of rotation.

The experience which will be obtained from these four applications of the internal combustion engine is being looked forward to with great interest and will provide data of extreme value. As regards the rules adopted by the Society for the survey of internal combustion engines using petrol or paraffin fuel, it is added that while the committee realize that they must look forward to modifications and developments in these rules as experience shows to be necessary, it is gratifying to know that the rules have been received with general approval as very fairly meeting the requirements of the present time. Similar rules applicable to the various types of Diesel engines are under consideration.—*Page's Weekly.*

Sir W. H. White has a letter in the *Spectator* on the subject of the use of internal combustion engines in the warships of the future. "It is undoubted," he says, "that the use of gas producers would secure economy of space and weight as compared with coal-fired steam boilers. On the other hand, it would be absolutely necessary to provide large supplies of air for the producers and the gas engines, and to arrange for getting rid of the products of gaseous explosions in the cylinders. Possibly these supply and exhaust passages would not involve so serious an interference with deck spaces and with large arcs of command of heavy guns as do the funnels and air shafts of ordinary steamships. On the other hand, these passages must necessarily be of large dimensions, and would require careful consideration if they are to do their work satisfactorily. Consequently, it is idle to assume, as has frequently been done, that the adoption of gas or oil engines would entirely overcome the difficulties which have to be faced in ordinary steamers. The method of dealing satisfactorily with the by-products from gas producers in ships of large engine power is also a matter as yet awaiting solution. In fact, as a writer said a year ago, when discussing this subject, 'a long road has to be travelled before the satisfactory use of internal combustion engines for ship propulsion will be secured.' The problem of evolving large units of power is necessarily difficult, and although success will probably be attained ultimately, a complete solution is not yet in sight."

It seems to be generally expected that the next step in the application of the principle of the gas-producer engine to naval purposes will be its instalation in a destroyer, or perhaps a cruiser. There are naturally many difficulties to be surmounted, but as the gas engine is bound to come sooner or later, nothing will be lost by the British Navy being first in the

field. The largest vessels actually in naval service which have internal combustion engines for propulsion appear to be those attached to the Austrian fleet for service on the Danube. Four such have been fitted by Messrs. Yarrow & Company with the new machinery, and have given satisfactory results on service. The first pair, which were constructed on the Clyde, were delivered in 1908, each being fitted with five 70-brake-horse-power Yarrow-Napier motors, which gave the boats a speed of 22¼ knots on trial, and it was found that at 11 knots the radius of action was at least three times as much as it would have been had the vessels been propelled by steam. Last year a second pair were ordered from an Austrian yard, for which Messrs. Yarrow supplied the engines. These four boats are in all essential respects similar to the little *Mercury II*, which our own Admiralty purchased in 1906, and from which satisfactory results have been obtained. The late King Edward, it may be recalled, took a trip in this vessel during Cowes week, 1907. But *Mercury II* only develops about 300 horse-power, and, as Sir Henry Oram pointed out in an address last year, we have a long way to go before there can be surety of success in large-power installations. But the fact that after a long absence Messrs. Yarrow's name appears in the list of destroyer builders for the new programme, they having contracted for two special boats, lends color to the report that one, if not both, of these may be experimentally fitted with the internal combustion marine system.—*Army and Navy Gazette.*

The Hamburg-American Line is having an 8000-ton motor-driven ship built for it by the Hamburg firm of Blohm & Voss. A new device will render the exhaust almost silent and the fumes of the gases will be invisible and odorless. The two three-cylinder engines, which will give the ship a speed of 12½ knots, are the joint product of the Maschinenfabrik Augsburg-Nürnburg and of Blohm & Voss. The residue in the process of the refinement of the oil only will be used as oil fuel. Only 27 persons will be needed for the oil engines, while in steam vessels of similar size about 250 stokers and coal drawers would be employed. Moreover, the motor liner, by space conservation thus obtained, can carry 2000 tons more cargo than her steam rival of similar dimensions.

MISCELLANEOUS.

AVIATION AND NAVAL WARFARE.—The object of hitting a ship with gun, torpedo, mine or bomb, is to put her out of action, or at least to diminish her fighting power by injuring her powers of movement or by putting out of action one or more of her guns. This elementary fact seems sometimes to be forgotten by people who talk as if the only thing necessary is to "hit" a ship somewhere, anywhere.

Now the only place where a ship can be hit by a bomb is the upper deck. A lucky shot certainly might fall down a funnel and do some damage in the stokehold, but considering what an infinitesimally small mark a funnel top would present from above, this chance is hardly worth serious heed. Even if it came off, the damage would probably do no vital injury to the ship.* An explosive dropped on the deck itself might certainly make a large hole and demolish some cabins and mess-places. It might cause an outbreak of fire; but it could not do much more. It certainly could not get through the protection of the armored deck and do injury to the engine room. Whatever object these bombs touch first—and that will be the deck—must cause them to explode; they cannot pos-

* It does not seem to have occurred to those who talk of destroying ships by dropping explosives down their funnels that a light grating near the funnel top would stop and explode a bomb, and so limit its effect to doing damage to the upper part of the stack.—P. R. A.

sess any of the qualities of heavy armor-piercing shells with fuse attached. As for injuring men, there will not be many men standing unprotected about the upper deck in action. The guns' crews will be in armored turrets or casemates, whose thick, curved tops should be proof against any damage from bombs. The officers and men on the bridge and in the control-positions are more liable to injury, as our ships are constructed at present, but it would be easy enough to build a "roof" of 6-inch armor over these small areas. The guns themselves remain as the only objects to be injured, and these, with their comparative smallness as objects for the aviator's aim, their thickness, and above all their cylindrical shape, which would render any blow from above a glancing one, may well be considered as needing no further protection against bombs. On the whole, then, we may safely say that, besides the chances of aiming straight at a ship being very precarious, in all probability not much damage would be done if the ship were hit.

What measures should be taken to guard against these very problematical dangers may now call for some comment. One might well be excused for thinking that the perils of aviation form in themselves a sufficient safeguard for any ship liable to be the object of attack. So long already is the list of honored martyrs to the science of aviation that one does not need to be reminded how perilous is the lot of those who trust themselves to the air. A wire stay breaks, the engine stops, the lubrication fails, a sudden gust of wind arises, the balloon becomes over-inflated through the sun's heat, and down to the ground comes the aviator, fortunate if he escapes with his life. This, too, in peace time, when flights are as a rule made under the most favorable atmospheric conditions. In time of war, when the aeronaut could not always wait until the elements were obliging enough to suit themselves to his needs, his natural dangers would magnify themselves a hundredfold. As has been said before in connection with another matter, improvements may be invented to lessen these dangers, but we have not yet arrived at the perfection of Kipling's airship in "Actions and Reactions," and with all due deference to him we are not likely to do so for a very long time. As things are at present, 50 aeroplanes and dirigibles might set out on an unfavorable day, and not one arrive near the enemy. Let us not be carried away by the highly colored imaginings of the writer of "The War in the Air," and all his host of imitators; the flying machine of fiction may be a very formidable monster, but the real thing is feeble enough, the sport of the wind and of a hundred mischances.

A most important point to be noticed is that every single thing which makes for the aviator's safety decreases his chances of shooting accurately, and, conversely, everything which makes for a correct aim adds to his own danger. If he flies low or slowly he comes within range of the enemy's guns, and gives them a longer time to shoot at him; if he flies high or swiftly it becomes all the more difficult for him to drop his bombs with accuracy.

Messrs. Krupp are said to have invented a gun to be used against air craft. Possibly, the gunmakers of other nations are experimenting with similar weapons. Is it necessary, though, to employ a special make of gun for this work? Against an airship appearing in the distance for the purpose of scouting alone, and not closing to make a bomb-dropping attack, the guns already in use both on land and at sea could be used. The elevation that can be given with all mountings now in use is sufficient for the projectile to reach the probable altitude of an airship at a distance of 4 or 5 miles. When the airship or aeroplane comes closer, however, with the object of making an attack, it seems scarcely necessary to make use of even the lightest guns. In most cases Maxim fire ought to be sufficient, with an effective range of about 2000 yards, within which the aviator is almost bound to come if his attack is not to be a farce. The aeroplane is singularly vulnerable; a very small shot could disable the engine or the propeller, or break stays and guys, when disaster would inevitably

result; while if a bullet should chance to hit the little stock of bombs, or the aviator himself, there would be no need even to lower a boat to pick up the pieces. There can be no question of armoring an aeroplane, or, for the matter of that, a dirigible either. The dirigible, too, is vulnerable to an immense degree. Possibly a direct hit straight through from side to side of one compartment of the gas chamber might not do much harm for awhile, but a single Maxim bullet, much more a shower of them, tearing through the envelope in a slanting direction, and so piercing nearly all the compartments at once, would bring down the best dirigible ever made. A weapon which fires a continuous stream of very small projectiles appears to be more suited for this work than any quick-firing gun that has to be aimed anew after each discharge. If a Maxim is not powerful enough, though it probably will be found to be so, some such weapon as the pom-pom could be employed, firing solid bullets instead of explosive shells.

Defence during the darkness of the night should not be so difficult as it might at first appear. The whirring of an airship's propeller can always be heard at some distance, and would betray her whereabouts. Whatever a dirigible might do, an aeroplane at all events cannot slow down like a destroyer to decrease the noise of her engines. The darkness itself would be as much in favor of an attacked ship as to the disadvantage of the aviator, and any naval officer who has been on a destroyer's bridge in a night attack and knows how dazzling a searchlight can be when directed straight in his eyes can imagine the chances of an aviator holding a straight course under similar circumstances. With the searchlight, the Maxim or pom-pom would come into play, and the night attack prove indeed a serious matter—for the aviator.

To conclude, the flying machine in all its various forms may or may not be a thing to be taken seriously as far as scouting and message-carrying and similar offices are concerned, but with regard to its use as a weapon of attack, the danger seems to the writer very much like the bomb from the air might itself well be—exploded before it arrives.—*Naval and Military Record.*

COST OF NAVIES.—A British Parliamentary return has been issued "of the naval expenditure of each of the principal naval powers, showing their total estimated naval expenditure in each of the last 10 years, their expenditure in each of the years named on new construction, including armament, and the amount of their new construction in each of those years expressed in tonnage."

By summing up the items in this return, the following figures were arrived at as representing the total amounts voted for new naval construction during the 10 years 1901-1910, inclusive, and the total tonnage (when completed) of warships launched during the same period:

	Total amount voted for new construction, including armanent.	New construction. Tons displacement.
Great Britain	$112,060,310	1,187,308 †
United States	63,285,504	603,454 *
Germany	63,144,330	522,220 *
France	46,804,261	366,737 *
Russia	31,606,620	294,209 *
Italy	15,361,938	121,034 *
Japan	11,991,643	97,940 *

† This includes an estimated tonnage of 226,872 tons launched in 1910.

* These figures do not include ships launched in 1910, and so are really only for 9 years.

A comparison of Japan's expenditure with that of the five other powers named is significant in view of the exaggerated statements current respecting her naval ambitions.

SUBMARINES AND MINES.—With the rise and progress of the submarine there has once again arisen the eternal question of the utility of the big ship and the possibility of its supersession by small units. We had it in the early eighties of the last century when Gabriel Charmes and *La Jeune Marine* thought that the boundless arrogance of perfidious Albion was at last to be held in check by the deadly new weapon which the world owed to Mr. Whitehead. But even as that phase arose, had its vogue, and then passed away, so it is to be anticipated will the one which has arisen in connection with that form of craft which has her local habitation "in the waters under the earth." As to whether in its generation the submarine is more or less formidable than its forerunner, the torpedo-boat, is a hard matter to determine without actual and practical experience in warfare; so far the submarine has not been tried in this way, and therefore all critics start from a common platform in discussing the subject. First and foremost in favor of this class of engine of destruction is its potential menace; and the effect which it cannot fail to have on the minds and the nerves of the combatants of the future. The battleship proudly riding the waves in her dominating magnificence fears no foe which can assail her on the element on which she floats; it is, however, quite another matter when her enemy is something which does not float, or, rather, one which does so beneath the surface, and the approach of which cannot be seen. The sensation experienced with regard to her may be likened to that of a man in a dark room, who knows that a foe lies lurking armed with a dagger which may at any moment pierce his vitals without his having a chance of retaliation. A sensation of this sort is apt to make cowards of the bravest, and therefore the mere menace of the submarine is one of her most effective assets. The periscope creeping through the shining blue water will cause the hearts of brave men to stand still in a way that no other danger could accomplish; for "the doom bolt in the darkness freed" may be upon them at any time, and the bottom blown out of their ship without any chance of retaliation.

In consequence of this it is to be presumed that blockade such as was known to our forefathers is now a thing of the past, and that which in the twentieth century is to represent St. Vincent's "close up to Ushant in an easterly wind" has yet to be invented, which means that owing to the menace of the submarine battle fleets will have to keep a respectful distance from the ports of the enemy. This much is admitted as an axiom of future naval warfare, but does this menace extend so very far after all? This is a question much easier to ask than to answer, as we are at present, so to speak, at the very beginning of things as far as the submarine is concerned. She is creeping up the scale of efficiency in a manner which would hardly have been deemed possible in the early days of these machines, and the end is very far from being in sight, as recent statistics concerning these craft prove. She has, of course, increased in size, in speed, in radius of action, in general mobility both on the surface and beneath it. In spite of this, however, she remains at present a small craft and not a big one, and we are all aware that "the conies are a feeble folk."

That which handicaps this particular class of cony is the fact that she is born blind, and no subsequent length of days on her part enables her to overcome this very serious initial disability. We grant readily the terrible destructiveness of the creature if only she can be brought to a point in which she can use the weapons with which she is provided; it is the getting her to that point in which all the difficulties reside. No man can see much under water; how very little he can see is easily demonstrated to anyone who will take the trouble to put on a diving dress and go down—not "bien entendu," by any means "into the depths," but a few feet only beneath the surface of the water on a bright and sunny day, at some place where the bottom of the sea is white and therefore shows up surrounding objects in the most favorable manner for underwater examination. The man who will take the trouble to do this will

find that if he sees an object on the floor of the sea from a standing position—which object will in the first instance have to be something white and shining to enable him to see it at all from the giddy elevation of his own height—that to discover what that something is, he will have to kneel down and place the glass front of his diver's helmet practically on to the top of it before he can swear as to its identity. This being so, the crews of submarine vessels can obviously see nothing at all once they are beneath the surface; their observation of the enemy whom they wish to attack must be taken on the surface. If, for instance, it is imagined that it is necessary to blockade an enemy's port in order to bring to action those ships which are sheltering within, it is true that without grave risk no fleet could remain in an inshore position for any length of time; such a method of procedure would be to invite disaster from the under-water craft of those in the harbor. At the same time, in these days of prodigious swiftness it would be quite possible for a fleet to maintain a position in the vicinity of the harbor which would at all events make it fairly certain of those within not getting out totally unobserved. By maintaining always a high rate of speed the difficulty of the defending submarines would be increased to a pitch which would render their success, in case of an attack by them (to say the least of it) extremely problematical. A fleet moving in detached order, in no regular formation, and steaming at a minimum speed of 15 knots per hour, would form a target which would take quite a lot of hitting. An attack in force by submarines on a fleet employed in such a duty might, indeed, have the effect of causing this fleet to haul off further from the base which it had been called upon to watch; at the same time it is, to say the least of it, doubtful if they could be driven so far afield that the imprisoned fleet could escape without being brought to action.

As our civilization increases and our manners soften, and we prate yet more insistently day by day of the blessings of peace, so do we concurrently invent more and more devilish inventions for the destruction of our fellow-men, and it is only quite recently that Mons. Charles Bos, the extremely able editor of *La Vie Maritime et Fluviale,* told us, that should Germany and England go to war, the former power would render that portion of the North Sea which she herself could not hope to control a veritable magazine by means of sowing in it hundreds and hundreds of mines which she keeps stored for this purpose in her principal dockyards at Kiel and Wilhelmshaven. From experience of what took place in the conflict between Russia and Japan it would appear that the use of these contrivances is not contrary to the law of nations, and—if this be the case—there really seems to be no reason to stand upon ceremony in such matters as poisoning wells and the use of expanding bullets, which heretofore have not been regarded as "cricket" in international disputes, and have been ruled out of the game in consequence. War is not a nice business at the best, but there is a devilish and calculated cold-bloodedness about the use of floating mines which even in these peace-loving and peace-professing days is a somewhat strong order.

Mines and submarines notwithstanding, there is no limitation to the output of battleships of the largest size, and, in order that brotherly love may ensue, the tale of their tonnage has now leaped up to the respectable figure of 32,000, while the merchant steamer is taking on even more gigantic proportions. The building of these immense unities proves to demonstration that as it was in the eighties so it is to-day—the men who know and are responsible for the naval armaments of the powers still pin their faith to those ships destined to lie in the line of battle. Further, that although not altogether unafraid of the menace of the submarine and the floating mine, they still put their trust in the last resort to the most powerful floating platform on which guns can be mounted. We see no reason why they should depart from this faith, for the large unit must always be of greater value than the small. This sounds like a ridiculous platitude, but what is wished to be expressed is that in scientific con-

struction and everything which makes of any vessel a formidable fighting asset to the country to which she belongs, the big ship is advancing *pari passu* with the small one. Speed on the part of the big ship is now one of her principal attributes, and the immense superiority which the torpedo-boat of the eighties possessed over the ironclad no longer obtains; indeed, it now may be said that the reverse of this is the case, the new large armored cruisers—which are battleships in all but name—being faster than the small craft of the present day. Neither speed, armament, nor even, it may be asserted, the most vigilant look-out can save any ship, great or small, from the menace of practical destruction from the floating mine; but the speed of the larger units will be their principal asset in the matter of escape from the submarine in time of war. We have had many controversies of late years concerning the different attributes of the big ship, and as to whether too much has not been, and is being, made of the quality of speed; whether or no precious space was not being sacrificed to the problematical utility of another knot or so. In this connection the controversy seems to have settled itself, as when submarines can move over the surface of the waters at 16 knots, and beneath them at the rate of 12, it is obvious that their prey in the shape of battleships and cruisers must be able to escape from their unwelcome attentions.—*Naval and Military Record.*

NAVAL REGULATIONS. *Ancient Customs and Punishments.*—The first authenticated instance where regulations for the conduct of the seamen of the British fleet were drawn up was during the reign of Richard I, in the latter part of the twelfth century. They were issued at Chinon, in France, while the King was on his way to Marseilles to join his fleet, which was subsequently to take part in the crusades to the Holy Land. Although perhaps from a modern point of view the regulations themselves seem severe, it must be remembered that in England the theft of a sheep was punishable by death until this was mitigated by Sir Robert Peel's Acts 9 and 10, George IV, 1829. Witches also were burnt alive as late as 1716, and in that year Mrs. Hicks and her daughter, aged 9, were hanged at Huntingdon for sorcery. Forgery was also punishable by death, according to the law of the land, the last victim being Thomas Maynard, who was executed at the Old Bailey on December 31, 1829.

The more important ordinances of the code issued by Richard I were as follows:

Anyone who should kill another person on board a ship should be tied to the dead body and cast into the sea.

Anyone killing another person on land should be tied to the dead body and buried with it in the earth.

Anyone lawfully convicted of drawing a knife or some other weapon with intent to strike another, or of striking another with the hand so as to draw blood, should lose his hand.

Anyone striking another with the hand, no blood being shed, should be dipped thrice in the sea.

Anyone uttering opprobrious or contumelious words to the insulting or cursing of another should, on each occasion, pay one ounce of silver to the injured party.

Anyone convicted of theft should have his head shaved and boiling pitch poured upon it, and feathers or down should be strewn upon it for the distinguishing of the culprit, and upon the first possible occasion he should be put ashore.

Rules were also drawn up for the officers, who were not permitted to lose more than 20 shillings in gambling in any one day or night under a penalty of a 100-shilling fine. The common seamen, however, were not permitted to gamble upon any occasion whatsoever, and in the event of their disobedience the culprits were to be dipped in the sea every morning for 3 days, or else pay a fine. This curious code of naval law may be taken as the forerunner of our present naval discipline act, articles of war, and King's regulations and Admiralty instructions.

Some four centuries later the instructions of Lords Howard of Effingham and Essex to the officers under their command for the expedition to Cadiz in 1596 are in some ways so similar to our present articles of war that they are well worthy of mention. One of them commands that prayers shall be offered up twice daily in each ship of the squadron, while another says:

You shall forbid swearing, brawling, diceing and such like disorders as may breed contention and disorders in your ships; wherein you shall also avoid God's displeasure and win His favor.

The above is remarkable, as it bears a strong resemblance to the clause in our present articles of war, which states:

Every person subject to this act who shall be guilty of any profane oath, cursing, execration, drunkenness, uncleanness, to the derogation of God's honor and the corruption of good manners, shall be . . . etc.

Further regulations with regard to stealing, the messing of the ship's companies, precautions for avoiding the danger of fire, the preservation of stores, cleanliness of the ships, station-keeping at sea, the conduct of a fleet in a fog, etc., were all drawn up at great length and with much exactitude of detail, and they really form the first instance of a classified list of definite rules and regulations for the conduct of the seamen under all possible circumstances.

With regard to the ordinance stating that Divine service is to be read twice daily in each of the ships, it is interesting to note that the regulations at the present time lay down that Divine service is to be read daily in all his Majesty's vessels. These ancient rules and regulations, although, according to all accounts, they were only intended as a rough guide, are extremely interesting as being the forerunners of our present ordinances. In the sixteenth century, however, the punishments usually fitted the crime, and it was left to the discretion of the commanding officers as to what should be done to the various offenders. Now, of course, a strict code is laid down as to the various punishments for different offences, and in the case of one seaman striking another and causing his nose to bleed, he would not have his hand cut off, but would probably be told to make friends and say no more about it.

It is curious, however, to think that only 320 years ago the punishment of death was carried out on any seaman who stole articles to the value of over 21 pence.—*Naval and Military Record.*

THE CBYNITE COMPASS.—Mr. S. H. Steward, the well-known optician of the Strand, has designed for night work a new luminous compass, which is a great advance on anything we have yet seen used for this purpose. The well-known Vernier principle of index line and outside circle of degrees is retained, but instead of the dial being painted with luminous paint, which needs exposure for a definite period to either sunlight or magnesium ribbon in order that it may be used at night, the new compass, which is called the "Cbynite," is treated with radium, which needs no previous exposure, but is always ready for night work and retains its luminosity for an indefinite period. The same principle has also been applied to the dial of a watch which is that of the ordinary pattern, with the addition of dots of radium on the outer edge of each figure to represent the hours and three dots—one each opposite 9, 12 and 3—to facilitate taking the time at night by indicating which way the watch should be held. The hands are recessed and also painted with radium. Here, again, the advantage of a watch which will be luminous at night without requiring previous exposure to sunlight or magnesium ribbon will be recognized by everyone.—*Army and Navy Gazette.*

THE WORLD'S OCEAN FREIGHT-CARRIERS.—The list of the world's ocean freight and passenger ships shows a gross decrease, when compared with that of a year ago, of 866 vessels, of 939,232 tons, taking cognizance only of vessels over 100 tons, and the same authority—*Lloyd's Register*—

notified some months ago a gross addition to the fleet from shipbuilding work of 1063 vessels, of 1,602,057 tons. We have thus a net increase in the world's fleet equal to 197 vessels, and 662,825 tons. Thus in one year we have added over 16 per cent to the merchant tonnage afloat. But the actual carrying capacity is even greater, for of the total tonnage built last year, only 64,487 tons were sailing craft, while the sailing vessels removed totalled 293,562 tons. Taking only steamers, the addition is nearly 900,000 tons. It results that as the trade of the world has not been augmented to anything like the same extent, there is less work for the existing tonnage to do, and with less work come greater competition, lower freights and less or no profit. Thus there is swept away any foundation for believing in an improvement in the shipbuilding trade in the near future. Until the over-sea trade increases at the same rate as the net addition to tonnage, there is little prospect of sound prosperity in merchant shipbuilding. a fact which the leaders of trade unions should strongly enforce on the men during these times of discontent and threatened strikes. This is the more important as there has been a greater tendency to break up old ships owing to them proving unremunerative under prevailing freight rates. Thus last year one-eighth of the tonnage removed, or 121,383 tons, came under this category, and of the total 47 per cent was British tonnage. This means an increased capacity per ton of ships on the ocean, as new tonnage is always more efficient in this respect than old shipping. Although, therefore, the total removals from all causes is 129,940 tons greater than in the previous year, and the highest for many years, the loss by misadventure—wrecks, founderings, collisions, etc.—is less, and therefore the list of lives lost is not augmented. Strandings and kindred casualties, which are comprised under the term "wrecked," are much the most prolific cause of disaster. To such casualties are attributable 53.5 per cent of the losses of steamers, and 57.5 per cent of sailing vessels. Cases of abandoned, foundered and missing vessels, more or less similar in the circumstances of loss, make up 20.8 per cent of the steamers and 23.6 per cent of the sailing vessels. As regards vessels owned in the United Kingdom. it is satisfactory to observe that the number of casualties comprised in these classes in the present return—viz., 26—is the lowest recorded since these wreck statistics have been compiled by *Lloyd's Register*. The annual loss of vessels belonging to the United Kingdom forms a very moderate percentage of the mercantile marine of the country—1.21—less than that of any of the other principal maritime countries, whose percentages of loss range up to 3.55 per cent of tonnage owned.—*Engineering*.

A NEW ORE UNLOADING RECORD.—An unusual performance in unloading iron ore was made September 3, 1910, at the Superior docks of the Pittsburgh & Conneaut Dock Company, at Ashtabula Harbor, Ohio. The four new Hulett 15-ton machines instaled at this dock unloaded 35,855 gross tons of ore from four vessels, working day and night shifts. The total average time for the four machines from start to finish was 20 hours 51 minutes. The total average lost time from shifting of vessels and machines and other causes was 1 hour 41 minutes. The net working time for the four machines was thus 19 hours 10 minutes. The amounts of ore unloaded from the respective vessels were as follows: *Schiller*, 10.788 tons; *Perkins*, 10,031 tons; *Sonoma*, 6478 tons; *Hebard*, 8558 tons. About 90 per cent of the ore was taken out by the machines independent of the shovelers, and the work of the latter consisted in shoveling the small amount of the ore from the corners and piling it under the buckets.

The best unloading record for a single cargo made with the four Hulett machines at Ashtabula Harbor was the performance of August 5, 1910, when 11,131 gross tons were taken out of the steamer *Thomas F. Cole* in 4 hours 30 minutes, net time. The *Cole* arrived at Ashtabula at 10.53 a. m. and left at 5 p. m., making the total time at dock 6 hours and 7 minutes, including an hour for dinner. The average rate of unloading was 630.6 tons per hour for each machine.—*Iron Age*.

ARMADA WRECKS. *"Treasure" Myths Exploded.*—Sir J. K. Laughton, the eminent authority on naval history, writes to *The Times:*

"As some interest as to relics of the Armada has been aroused during these last few weeks by the prominence given to the exaggerated story of the Tobermory Treasure Ship, I will ask you to allow me to offer some general observations on them. There is a very general impression all round our coasts, in England as well as Scotland, that every article of Spanish origin which may be fished up from the adjacent sea is a relic of the Armada. The most common of these 'relics' is a chest, always a 'treasure' chest, though I do not recollect that the treasure was ever found in them. I fancy that it would not be difficult to collect, in the south of England alone, more of these 'treasure' chests than there were ships in the Armada. They, or at any rate many of them, are handsome pieces of furniture, and are undoubtedly Spanish; but not more than half a dozen of them, at the very most, can have come from the Armada. The treasure myth may be dismissed, to keep company with the other exploded myths—the missionaries, the inquisitors and the chains for the heretics or the enslaved.

"Every now and again the public is startled by the announcement of guns or anchors, relics of the Armada, being found in the Downs. But we have the exact story of the voyage of the Armada, from the time of its first appearance off the Lizard until Lord Howard bade farewell to it off the Firth of Forth, and we can say positively that not a single ship of it came into or near the Downs, and could not, therefore, leave guns or anchors there. I have not seen any of these finds, but presume they are, or at least may be, remains of the Spanish fleet which was destroyed there by Tromp in 1639. Only a few weeks ago I read that one ship of the Armada, the *Santa Catalina* ('en que iba,' I suppose, D. Guzman Soto-mayor de Sota) was wrecked on Lundy. There is not an atom of evidence, not a hint, that any ship of the Armada came through St. Patrick's Channel. Many wrecks, many Spanish wrecks even, there may have been on Lundy, but not of the Armada. There are numerous stories of the same kind, and probably equally fabulous. One, which is true, appears, when we consider the facts of it, more curious in the reality than any which has been imagined. The *San Pedro Mayor*—which appears in the list as of 581 tons, 213 soldiers and 28 mariners—was wrecked somewhere near Bolt Head on or about November 3. That is certain, but how she got there is not recorded. As she appears to have been with the fleet originally, the presumption is that, after passing round Ireland, she stood to the eastward, intending, perhaps, to sight Ushant, but got caught by the northerly (Rennell's) current, which runs with exceptional force after a westerly gale, and was so swept on to the Devon coast. There are several instances even of a much later date of ships finding themselves in the Bristol Channel when their reckoning showed them in the fairway of the English Channel.

"What people resolutely forget or ignore is our long and friendly intercourse with Spain. For nearly a hundred years before the coming of the Armada this was peculiarly intimate; numbers of Englishmen settled in Spain, numbers of Spaniards settled in England, and the going and coming was frequent. In those days of inaccurate survey and inefficient lighting, the dangers of the deep were multiplied enormously; there must have been hundreds of wrecks of which history knows nothing, and legend has transferred them all to the Armada. From the nature of things these must have been most numerous on the coast of Cornwall; and besides wrecks there must have been much trade in a small way, much social mingling, many marriages. It might be a question whether some of the chests, already spoken of, did not reach this country with a bride's trousseau inside, or choice merchandise. The possibilities are numerous. It is more than probable that there is a strong Spanish element in the Cornish population, one indication of which is perhaps revealed in the Cornish name of Jago."

WIRELESS TELEGRAPHY AND TELEPHONY. *A Review of Recent Progress, by H. Marchand.*—In a former article (translated in *Scientific American Supplement,* No. 1770, December 4, 1909) an account was given of the progress made in wireless telegraphy and telephony in 1907 and 1908. The improvements introduced in 1909 have followed the same tendency toward a more general adoption of sustained or feebly damped oscillations.

1. *Generation of Waves.*—The method of mechanical generation has not been extended in practice, although patents have been obtained by the American General Electric Company for alternators of high frequency, and the question has been discussed by the American Association of Electrical Engineers. Marconi has instaled his disk spark-producer at the Poldhu station. Balsillie has formed a company for the exploitation of a spark-producer which consists essentially of a cylinder bearing long, curved teeth and revolving between two rows of fixed teeth. The cylinder is 6 inches in length and produces 30 sparks on each side. The interval between discharges is very small, but the rotation produces great pressure and resistance between the fixed and moving teeth. A tension of 15,000 volts is employed. Fessenden also employs a rotary disk apparatus, especially in the stations of the United States Navy, with a tension of 12,500 or 25,000 volts.

The most important of recent improvements in methods derived from that of Poulsen have been introduced by Jeance and Colin, who have succeeded in establishing regular telephonic communication over unprecedented distances. These experimenters have ingeniously overcome the difficulties of the Poulsen method and utilized all of its advantages by producing the arc in an atmosphere of hydro-carbon vapors between a thin carbon pencil and a copper bowl cooled by circulation of water. The waste of the carbon pencil is exactly compensated by a deposit of carbon resulting from the dissociation of the hydro-carbons, and the operation is perfectly uniform when the apparatus has once been adjusted. Three arcs in series are used, with an aggregate tension of 700 volts.

Collins, in America, continues to use his arc of 2500 or 5000 volts, formed between two disks rotating in a transverse magnetic field, which elongates the arc by "blowing." Jeance and Colin reject this artifice, deeming that its only useful effect is to fix the arc at a definite point. The Collins process, with others invented by De Forest and Fessenden, have been submitted to the United States Navy. Collins estimates that his method will satisfy the required conditions of operation over 100 miles without regulation for 5 minutes. He is now making an exhaustive study of the phenomena of the electric arc, and experimenting with a new thermo-electric detector.

The Polyfrequenz Elektricitaets Gessellschaft, which is exploiting the Peukert patents; the Wireless Syndicate, proprietor of the processes of Lepel and Burnstyn, and the Gesellschaft fuer Drahtlose Telegraphie have described methods which appear to be very much alike, and to be founded upon a principle which was announced by Wien in 1907, viz., the employment of short sparks in a greatly damped circuit, connected inductively with a second circuit which has very little damping. The radiant energy, in the form of sustained waves, is furnished entirely by the secondary circuit.

For the regular operation of this system it is necessary, according to Peukert, to form the electrodes of difficultly fusible metals, strongly cooled. In the apparatus of the Polyfrequenz Company the electrodes are disks of pure electrolytic copper, silver on their opposing faces, and placed close together in a box. If necessary, a drop of alcohol is introduced between the electrodes. The upper disk is movable. The electrodes may be cooled by water or air and may be revolved by an electric motor. In Peukert's apparatus the dielectric is usually air. Other inventors have tried mica but without success, as this mineral becomes an electrolyte after it has been used for some time. In Lepel's apparatus the disks are

separated by paper. Hence they can be piled on each other, and an almost unlimited tension and power can be employed. Peukert, however, prefers to use a number of separate elements. With one element connected with a circuit furnishing direct current at 220 volts, or alternating current at a few hundred volts, it is possible to send messages more than 100 miles. The Polyfrequenz Company seldom finds it necessary to use more than three elements. Direct or alternating current may be used indifferently. The alternating current possesses the advantage of yielding the required voltage more readily. According to Lepel, if direct current is used the electrodes should be of different metals (for example, the cathode of bronze and the anode of copper) and separated by a fraction of a millimeter.

From the above description it is evident that the new methods differ radically from the old ones, over which, according to their inventors, they have the marked advantage of making possible the employment of comparatively low tensions and greatly simplified inductance coils, condensers, keys, etc. The Polyfrequenz Company uses condensers insulated by sheets of paper. In the Lepel system sheets of mica are employed in the condensers.

Short-spark generators possess a very high efficiency. The loss in transforming direct, or low-frequency, to high-frequency current is less than 40 per cent. Hence the efficiency is at least four times that of Poulsen's method. These claims have been, in part, substantiated by experiments made independently of the exploiting companies. The consumption of energy is further reduced by the fact that the short spark is formed instantaneously.

II. *Reception of Waves.*—In the methods which employ sustained waves, direct reception by a telephone receiver is not possible, because the frequency is too great to produce an audible sound, and the waves do not form periodic trains, like the waves formed by the ordinary spark. The function of the instrument called the ticker, which was described in a previous article, is to interrupt these sustained waves in such a manner as to produce sound in the telephone. To dispense with the ticker is the object of the projections introduced in the disks of the Marconi apparatus, and of various devices employed by Balsillie, Fessenden and others. It is desirable to eliminate this accessory in order that all stations may be able to communicate with each other, and it is largely because this desideratum is not satisfied by the Poulsen method that this method has met with much opposition and has not come into extensive use.

The ticker can be dispensed with when, as in the methods of Marconi, Balsillie, etc., an oscillating system is employed which produces waves of periodically varying amplitude. A simple method of satisfying this condition, which is used for important stations in the Peukert system, consists in employing an alternator of such a frequency, 500 cycles per second for example, that an audible sound is produced by the successive groups of waves.

In this case the telephone gives a musical sound, which is very agreeable to the ear and makes the signals clearly distinguishable from noises produced by disturbing influences. The same system is employed by Fessenden with the rotary interrupter. The discharging points are so arranged that they produce one discharge for each alternation of the current.

Rectifying and electrolytic receivers are still being studied. Jégou has devised an electrolytic receiver which requires no battery. For wireless telephony, thermo-electric detectors, and vacuum-tube detectors based on the Edison effect, appear to find much favor. On the other hand, Rossi has constructed a very simple electro-magnetic receiver, a sort of bifilar Einthoven galvanometer, and De Forest has devised a multiple hysteresis detector, a modification of that of Marconi. Balsillie employs a similar apparatus which, he claims, is as sensitive as the best of the known receivers and is, at the same time, far less delicate and more regular in

operation. Collins announces the completion of a thermo-electric detector sensitive to oscillations, the energy of which is only 1/5000 erg.

III. *Working Methods.*—The list of patents relating to wireless telegraphy contains a large proportion of patents for methods of operation. The outsider would be surprised by this diversity of methods proposed for what appears at first glance to be the simplest part of the problem; but practical workers in wireless telegraphy understand the importance of this feature. In the infancy of wireless telegraphy many practical difficulties were caused by imperfection in the transmitting apparatus.

With methods employing the arc, which is not formed instantaneously, it is impossible to control the circuit directly by the transmitting key. The general practice is to produce a continuous train of waves and to give the signals by modifying their frequency. Various devices have been invented for this purpose: Alternation of resistance and other electric constants, interruption of the current of hydro-carbon vapor in which the arc is formed, etc. The composition of the hydro-carbon mixture may also be varied. The employment of short sparks greatly simplifies the question, and this is an especial advantage of this method, in which it is necessary to generate waves only during the passage of each signal, instead of maintaining a continuous electric discharge. In Balsillie's system, as in ordinary telegraphy, the key acts directly on the transmitting current, and also serves as a commutator in passing from transmission to reception. For the arc system Peukert inserts the key as a shunt to the arcs. This produces regularity of operation, but diminishes the efficiency.

In wireless telephony there are various systems of influencing the radiations by the use of the microphone. In the simplest method, which has been adopted by De Forest, Fessenden, Poulsen, Majorana and others, the microphone is intercalated in the circuit of the transmitting antenna, so as to vary the ohmic resistance of the circuit. This process, however, can be used only for communication over a very short distance with small power. For, with the exception of a few types which have not yet been introduced into practice, microphones, as now constructed, cannot well be used continuously with currents of more than 1 ampere.

In another method the microphone acts inductively on a coil inserted in the antenna circuit, but the variations of amplitude thus obtained are too small for long-distance transmission. The writer has suggested placing the microphone as a shunt to the battery. In this way a powerful current can be modified by means of an ordinary microphone, but this arrangement is not satisfactory in point of efficiency. Other systems have been devised by Fessenden, De Forest, Collins and Majorana. Jeance and Colin employ a number of microphones containing no combustible matter, which are connected between the earth and a properly selected point of a Tesla coil connected with the antenna. The current which flows through this branch circuit is regulated by the insertion of a variable resistance, inductance and capacity, so that its strength is one-tenth that of the main antenna circuit. Using instruments capable of supporting a current of 0.8 ampere, Jeance and Colin found no difficulty in modulating the electric energy required for telephonic transmission over a distance of 150 miles.—Translated for the *Scientific American Supplement* from *La Revue des Sciences Pures et Appliquées.*

BOOK NOTICES.

"The Campaign of Chancellorsville"—A Strategic and Tactical Study. By John Bigelow, Jr., Major U. S. Army, Retired, Author of "Mars-la-Tour and Gravelotte," "The Principles of Strategy," and "Reminiscences of the Santiago Campaign." With 47 maps and plans.

The campaign of Chancellorsville presents a greater variety of military problems than any other in which an army of the United States has taken part, and no other one approaching it in importance has been so imperfectly understood.

The author's object in describing it has been not only to tell what was done, but how it was done; to present a characteristic or typical view of the conditions and methods of troop-leading that obtained during our Civil War; and to do this in a way to interest and instruct the general reader as well as the military student. The fact that the New York *Sun* has devoted a page of its Sunday issue for three successive weeks to an exhaustive review of this book speaks volumes as to its importance.

The work is divided into two parts. Part I, entitled "The Period of Preparation," covers the time from the appointment of General Hooker as commander of the army of the Potomac, January 25, 1863, to the issuing of orders for the movement of the army, April 26, 1863. It treats of the reorganization and general improvement of the army preparatory to the campaign; of the scouts, raids and forays of Mosby and Fitzhugh Lee; of the first battle of Kelley's Ford, and of other minor operations. Part II, entitled "The Period of Operation," treats of the march to Chancellorsville; of the marching and fighting in the Wilderness; of Sedgwick's attempt to reach Chancellorsville, including the battles of Marye's Heights and Salem Church; of Stoneman's raid against Lee's communications; and of Jones's and Imboden's raids against the Baltimore and Ohio Railroad. Account is taken also of the operations on and near the peninsula of Virginia, so far as they seem to affect the situation of the main armies and of the navy in supporting the army of the Rappahannock on the James and York Rivers. From the issuing of the first order for the movement of the Army of the Potomac, April 26, to the recrossing of the Rappahannock, May 6, the operations of the forces on both sides are described and discussed day by day.

A unique feature of this work is its abundance of maps compiled from the most authentic sources, showing the positions of the opposing forces at successive stages of the operations described. In short, the work supplies what is probably the most thorough and exhaustive study of American military operations ever undertaken, and its historical value is proportionately great. The forty-seven maps—which have been repro-

duced in three colors by means of lithography—cannot be surpassed for clearness and precision.

The presswork is of the highest character and there will be only one thousand copies printed from type, which will be distributed on the completion of the printing.

In size the book is Royal Octavo, size 8¼ by 12, about 400 pages. Boxed, net $10.00, carriage additional. Published by the Yale University Press, 70 Fifth Avenue, New York.

"Nautical-Technical Dictionary." Containing the Terminology of Aeronautics, Artillery, Astronomy, Carrier Pigeon Service, Shipbuilding (Iron and Wood), Electricity, Sea Fisheries, Hydrography, The Complete Matériel of the Navy, Mathematics, The Building and the Working of Engines, Mechanics, Navigation, Photography, Physics, Maritime Trade and Insurance, Maritime Law, Naval Tactics, Mechanical Technology, etc. II Volume, Part I and II. French, English, German and Italian; English, French, German and Italian. Compiled by Julius Heinz, Retired Rear-Admiral, Austrian-Hungarian Navy. Published by the Editors of the *Mitteilungen aus dem Gebiete des Seewesens.* Sold by Löscher & Co., 307 Corso Umberto I, Rome, and by Asker & Co., 14 Bedford St., London. Price 20s 8d per volume.

In the compilation of the second volume, Part I and II, of the "Nautical-Technical Dictionary" the intention has been to produce a dictionary in four languages, which shall contain as many essentially naval and military expressions as possible, as also such as are connected with the sea service since the latter—especially in recent times—is also of considerable importance to other scientific professions, trades and branches of industry.

Therefore, the object was to compile a book which should be of use not only to officers of the navy and mercantile marine, to shipbuilders and engine constructors, to hydrographers, electricians, artillerists, aeronauts, mechanics, technologists, experts and those employed in mercantile classification, to shippers and yachtsmen, to consular officials and marine administrators, insurers and their clients, but also to all who take an interest in maritime affairs.

The arrangement of this last part of the complete work—"Nautical-Technical Dictionary in four languages" by E. Dabovich[1] and "Supplement to the first volume of the Nautical-Technical Dictionary" by Rear-Admiral (retired) J. Heinz[2] have already been published on this principle—is on the whole alphabetical, but in cases where it seemed necessary the authors have proceeded systematically, and after certain principal words have inserted other technically arranged expressions, which are connected with these catchwords. The object of this latter arrangement was to facilitate the finding of the nomenclature of the constituent parts of an important object, and also of such expressions as have had to be inserted after this part of the dictionary had already been completed.

While the dictionary was in course of construction, the orthographic change in the German language took place, which change could not be

[1] Price 12s. 6d.

[2] Price 16s. 8d.

taken into consideration as the work was already too far advanced. For the sake of uniformity, therefore, the former German orthography has also been retained in this part of the work.

The rendering of German and Italian into French and English naturally presented considerable difficulties, since this work necessitated a thorough grasp of the two last mentioned languages.

The revision of the first volume of the "Nautical-Technical Dictionary," as well as of the "Supplement" for the purpose of obtaining materials for the second volume, has been performed by the former chief of the eighth division of the Marinetechnisches Komitee, Commander (retired), E. v. Normann-Friedenfels, assisted by Lieutenants Ritter v. Pozzi, Schloszarek, Sandor de Vist and v. Hayek. The compilation of the greater part of the text of the second volume as well as the additions rendered necessary by recent progress, has been entrusted to Rear-Admiral (retired) Julius Heinz, who, it is regretted, did not live to see the publication of the book to the production of which he devoted so much labor. The above mentioned admiral was assisted by Lieutenants E. Dworski, M. Wickerhauser, E. v. Förster, B. Dittrich, M. Wöss and P. R. v. Ferro, Captain (retired) L. Pichl has completed the work.

The revision of the proof sheets, as far as the foreign expressions were concerned, was undertaken by Admiral Sir Ed. Tracey, K. C. B., of the Royal British Navy, and after his death by Lieutenant I. A. Duncan, Superintendent of the Research Department, Woolwich arsenal, by Captain (retired) H. de Saulses de Freycinet, Captain J. Chardon and Lieutenant T. Somborn, of the French Navy, and by the late Captain A. Lucifero, of the Royal Italian Navy. The above mentioned officers have given the most valuable assistance in the production of the work.

The printing of the work was superintended by the editor of the *Mitteilungen aus dem Gebiete des Seewesens.*

This is Part II of the book of which Part I was published in 1905 and noticed in the PROCEEDINGS for September of that year. The entire volume, now available, will be of the greatest value to all whose avocations or pursuits require an understanding of nautical and technical terms in foreign languages or the conversion of such terms from one language to another.

LIST OF PRIZE ESSAYS.

1879.

Naval Education. Prize Essay, 1879. By Lieut.-Com. A. D. Brown, U. S. N.

NAVAL EDUCATION. First Honorable Mention. By Lieut.-Com. C. F. Goodrich, U. S. N.

NAVAL EDUCATION. Second Honorable Mention. By Commander A. T. Mahan, U. S. N.

1880.

"The Naval Policy of the United States." Prize Essay, 1880. By Lieutenant Charles Belknap, U. S. N.

1881.

The Type of (I) Armored Vessel, (II) Cruiser best suited to the Present Needs of the United States. Prize Essay, 1881. By Lieutenant E. W. Very, U. S. N.

SECOND PRIZE ESSAY, 1881. By Lieutenant Seaton Schroeder, U. S. N.

1882.

Our Merchant Marine: The Causes of its Decline and the Means to be taken for its Revival. "Nil clarius aquis." Prize Essay, 1882. By Lieutenant J. D. J. Kelley, U. S. N.

"MAIS IL FAUT CULTIVER NOTRE JARDIN." Honorable Mention. By Master C. G. Calkins, U. S. N.

"SPERO MELIORA." Honorable Mention. By Lieut.-Com. F. F. Chadwick, U. S. N.

"CAUSA LATET: VIS EST NOTISSIMA." Honorable Mention. By Lieutenant R. Wainwright, U. S. N.

1883.

How may the Sphere of Usefulness of Naval Officers be extended in Time of Peace with Advantage to the Country and the Naval Service? "Pour encourager les Autres." Prize Essay, 1883. By Lieutenant Carlos G. Calkins, U. S. N.

"SEMPER PARATUS." First Honorable Mention. By Commander N. H. Farquhar, U. S. N.

"CULIBET IN ARTE SUA CREDENDUM EST." Second Honorable Mention. By Captain A. P. Cooke, U. S. N.

1884.

The Reconstruction and Increase of the Navy. Prize Essay, 1884. By Ensign W. I. Chambers, U. S. N.

1885.

Inducements for Retaining Trained Seamen in the Navy, and Best System of Rewards for Long and Faithful Service. Prize Essay, 1885. By Commander N. H. Farquhar, U. S. N.

1886.

What Changes in Organization and Drill are Necessary to Sail and Fight Effectively Our Warships of Latest Type? "Scire quod nescias." Prize Essay, 1886. By Lieutenant Carlos G. Calkins, U. S. N.

The Result of all Naval Administration and Efforts finds its Expression in Good Organization and Thorough Drill on Board of Suitable Ships. Honorable Mention. By Ensign W. L. Rodgers, U. S. N.

1887.

The Naval Brigade: its Organization, Equipment and Tactics. "In hoc signo vinces." Prize Essay, 1887. By Lieutenant C. T. Hutchins.

1888.

Torpedoes. Prize Essay, 1888. By Lieut.-Com. W. W. Reisinger, U. S. N.

1891.

The Enlistment, Training and Organization of Crews for our Ships of War, Prize Essay, 1891. By Ensign A. P. Niblack, U. S. N.

Disposition and Employment of the Fleet: Ship and Squadron Drill. Honorable Mention, 1891. By Lieutenant R. C. Smith, U. S. N.

1892.

Torpedo-boats: their Organization and Conduct. Prize Essay, 1892. By Wm. Laird Clowes.

1894.

The U.S.S. Vesuvius, with Special Reference to her Pneumatic Battery. Prize Essay, 1894. By Lieut.-Com. Seaton Schroeder, U. S. N.

Naval Reform. Honorable Mention, 1894. By Passed Assistant Engineer F. M. Bennett, U. S. N.

1895.

Tactical Problems in Naval Warfare. Prize Essay, 1895. By Lieut.-Com. Richard Wainwright, U. S. N.

A Summary of the Situation and Outlook in Europe. An Introduction to the Study of Coming War. Honorable Mention, 1895. By Richmond Pearson Hobson, Assistant Naval Constructor, U. S. N.

Suggestions for Increasing the Efficiency of Our New Ships. Honorable Mention, 1895. By Naval Constructor Wm. J. Baxter, U. S. N.

The Battle of the Yalu. Honorable Mention, 1895. By Ensign Frank Marble, U. S. N.

1896.

The Tactics of Ships in the Line of Battle. Prize Essay, 1896. By Lieutenant A. P. Niblack, U. S. N.

The Organization, Training and Discipline of the Navy Personnel as viewed from the Ship. Honorable Mention, 1896. By Lieutenant Wm. F. Fullam, U. S. N.

Naval Apprentices, Inducements, Enlisting and Training. The Seaman Branch of the Navy. Honorable Mention, 1896. By Ensign Ryland D. Tisdale, U. S. N.

The Composition of the Fleet. Honorable Mention, 1896. By Lieutenant John M. Ellicott, U. S. N.

1897.

Torpedo-boat Policy. Prize Essay, 1897. By Lieutenant R. C. Smith, U. S. N.

A PROPOSED UNIFORM COURSE OF INSTRUCTION FOR THE NAVAL MILITIA. Honorable Mention, 1897. By H. G. Dohrman, Associate Member, U. S. N. I.

TORPEDOES IN EXERCISE AND BATTLE. Honorable Mention, 1897. By Lieutenant J. M. Ellicott, U. S. N.

1898.

Esprit de Corps: A Tract for the Times. Prize Essay, 1898. By Captain Caspar Frederick Goodrich, U. S. N.

OUR NAVAL POWER. Honorable Mention, 1898. By Lieut.-Com. Richard Wainwright, U. S. N.

TARGET PRACTICE AND THE TRAINING OF GUN CAPTAINS. Honorable Mention, 1898. By Ensign R. H. Jackson, U. S. N.

1900.

Torpedo Craft: Types and Employment. Prize Essay, 1900. By Lieutenant R. H. Jackson, U. S. N.

THE AUTOMOBILE TORPEDO AND ITS USES. Honorable Mention, 1900. By Lieutenant L. H. Chandler, U. S. N.

1901.

Naval Administration and Organization. Prize Essay, 1901. By Lieutenant John Hood, U. S. N.

1903.

Gunnery in Our Navy. The Causes of its Inferiority and Their Remedies. Prize Essay, 1903. By Professor Philip R. Alger, U. S. N.

A NAVAL TRAINING POLICY AND SYSTEM. Honorable Mention, 1903. By Lieutenant James H. Reid, U. S. N.

SYSTEMATIC TRAINING OF THE ENLISTED PERSONNEL OF THE NAVY. Honorable Mention, 1903. By Lieutenant C. L. Hussey, U. S. N.

OUR TORPEDO-BOAT FLOTILLA. The Training Needed to Insure its Efficiency. Honorable Mention, 1903. By Lieutenant E. L. Beach, U. S. N.

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A PLEA FOR A HIGHER PHYSICAL, MORAL AND INTELLECTUAL STANDARD OF THE PERSONNEL FOR THE NAVY. Honorable Mention, 1904. By Medical Inspector Howard E. Ames, U. S. N.

1905.

American Naval Policy. Prize Essay, 1905. By Commander Bradley A. Fiske, U. S. N.

THE DEPARTMENT OF THE NAVY. Honorable Mention, 1905. By Rear-Admiral Stephen B. Luce, U. S. N.

1906.

Promotion by Selection. Prize Essay, 1906. By Commander Hawley O. Rittenhouse, U. S. N.

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1907.

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1908.

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1910.

The Merchant Marine and the Navy. Prize Essay, 1910. By Naval Constructor T. G. Roberts, U. S. N.

The Naval Strategy of the Russo-Japanese War. Honorable Mention, 1910. By Lieutenant Lyman A. Cotten, U. S. N.

INDEX TO VOLUME 36

Alger, Philip R., Professor, U. S. N. Annual Report of Secretary and Treasurer, 334.

——— A Study of Naval Strategy. Translation, 125, 391.

——— Discussion, 1141.

——— Erosion and Ballistics: A Rejoinder, 975.

——— Gun Erosion, 697.

——— On a Method of Measuring the Resistance of Metals to Rapid Deformations. Translation, 987.

——— Professional Notes, 268, 595, 857, 1149.

——— The Genius of Naval Warfare. II. Tactics. Translation, 753, 991.

——— The Influence of Velocity on the Law of Deformation of Metals. Translation, 985.

American Naval Vessels, Early Voyages of, to the Orient. Paullin, C. O., 429, 707, 1073.

Antiquaries, A Society of Nautical, 593.

Aquino, Radler de, Lieutenant, Brazilian Navy. A Nomogram for Compass Deviations, with an Elementary Exposition of the two Parallel Scale Nomograms. Translation, 1043.

Ballistics, Erosion and. A Rejoiner. Alger, P. R., 975.

Ballistics, Some Comments on Erosion and. Yarnell, H. E., 965.

Book Notices, 330, 648, 921, 1201.

Charts, A Suggestion about. Fiske, B. A., 1071.

Compass Deviation, A Nomogram for, with an Elementary Exposition of two Parallel Scale Nomograms. Pesci, G. Translated by Lieutenant R. de Aquino, Brazilian Navy, 1043.

Cotten, L. A., Lieutenant, U. S. N. The Naval Strategy of the Russo-Japanese War, 41.

Cruise, An Early Globe Circling. Maclay, E. S., 481.

Cunningham, A. C., Civil Engineer, U. S. N. The Development of the Norfolk Navy Yard, 221.

Cutler-Hammer Manufacturing Company's Differential System of Turret Training Gear, The. Bullard, W. H. G., 543.

Daveluy, R., Commander, French Navy. A Study of Naval Strategy. Translation by P. R. Alger, 125, 391.

——— The Genius of Naval Warfare. II. Tactics. Translation by P. R. Alger, 753, 991.

Deformation of Metals, The Influence of Velocity on the Law of. Vieille, P. and Liouville, R. Translated by Philip R. Alger, U. S. N., 985.

Deformations, On a Method of Measuring the Resistance of Metals to Rapid. Vieille, P. and Liouville, R. Translated by Philip R. Alger, U. S. N. 987.

Denney, A. D., Midshipman, U. S. N., and Lee, W. A., Jr. Revolver Shooting, 249.

Destroyer, The—Our Naval Weakness. Stirling, Yates, Jr., 469.

Diameter of a Ship, A New Method for Determining the Final. Taylor, D. W., 501.

Dillingham, A. C., Rear Admiral, U. S. N. U. S. Naval Training Service, 343.

Discussions, 263, 587, 855, 1141.

Earle, Ralph, Lieut.-Commander, U. S. N. Discussion, 1141.

Erosion and Ballistics, Some Comments on. Yarnell, H. E., 965.

Erosion and Ballistics: A Rejoinder. Alger, P. R., 975.

Erosion, Gun. Alger, P. R., 697.

Explosives, Some Modern Developments in Methods of Testing. Munroe, C. E., 805.

Farenholt, A., Surgeon, U. S. N. Notes Concerning the Origin of Some of the Institutions of the British Navy, 835.

Final Diameter for a Ship, A New Method of Determining. Taylor, D. W., 501.

Fiske, Bradley A., Captain, U. S. N. An Unprecedented Rescue, 957.

——— A Suggestion About Charts, 1071.

——— Incorrect Adjustment of Range Finders, 1060.

Fleet, The Organization of. Hood, John, 825.

Foley, Paul, Lieutenant, U. S. N. The Naval Academy Practice Cruise, Its Organization Along Modern Lines, 239.

Freighter, Random Notes on a Lake. Goodrich, C. F., 943.

Gatewood, R. D., Assistant Naval Constructor, U. S. N. More Light on Shipboard, 1059.

——— The Motor Drive, 507.

Genius of Naval Warfare, The. II. Tactics. Daveluy, R. Translated by Philip R. Alger, U. S. N., 753, 991.

Goodrich, C. F., Rear Admiral, U. S. N. Random Notes on a Lake Freighter, 943.

Goodwin, H. B., The Haversine in Nautical Astronomy, 735.

Gun Erosion. Alger, P. R., 697.

Haversine, The, in Nautical Astronomy. Goodwin, H. B., 735.

Hood, John, Captain, U. S. N. The Organization of the Fleet, 825.

Institutions of the British Navy, Notes Concerning the Origin of. Farenholt, A., 835.

Knapp, H. S., Captain, U. S. N. The Real Status of the Panama Canal as Regards Neutralization, 61.

Lake Freighter, Random Notes on. Goodrich, C. F., 943.

Lee, W. A., Jr., Midshipman, U. S. N., and Denney, A. D. Revolver Shooting, 249.

Light on Shipboard, More. Gatewood, R. D., 1059.

Liouville, R. and Vielle, P. On a Method of Measuring the Resistance of Metals to Rapid Deformations. Translation by P. R. Alger, 987.

Liouville, R. and Vielle, P. The Influence of Velocity on the Law of Deformation of Metals. Translation by P. R. Alger, 985.

Luce, S. B., Rear-Admiral, U. S. N. Naval Training. II, 103.

——— The U. S. Naval War College, 559.

——— The U. S. Naval War College (Concluded), 683.

Maclay, Edgar Stanton, A. M. An Early Globe Circling Cruise, 481.

Magruder, T. P., Lieut.-Commander, U. S. N. The Enlisted Personnel, 375.

Maxim, Hudson. Discussion, 1145.

McCabe, William Gordon. Discussion, 265.

McIntosh, H. B., Lieutenant, U. S. N. Concerning the Tactical Employment of Torpedo-Boats. Translation, 1101.

McNamee, L., Lieut.-Commander, U. S. N. The Present Day Problem of Ship Propulsion, 747.

McNeely, R. W., Lieut.-Commander, U. S. N. Discussion, 1147.

Merchant Marine and the Navy, The. Roberts, T. G, 1.

Metals, On a Method of Measuring the Resistance of, to Rapid Deformation. Vieille, P. and Liouville, R. Translated by Philip R. Alger, U. S. N., 987.

Metals, The Influence of Velocity on the Law of Deformation of. Vieille, P. and Liouville, R. Translated by Philip R. Alger, U. S. N., 985.

Morrison, F. W., Notes on the Solution of the Triangle of Position without Trigonometrical Computation. Translation, 529.

Motor Drive, The. Gatewood, R. D., 507.

Munroe, Charles E., Some Modern Developments in Methods of Testing Explosives, 805.

Naval Academy Practice Cruise, Its Organization along Modern Lines. Foley, Paul, 239.

Nautical Astronomy, The Haversine in. Goodwin, H. B., 735

Naval Strategy, A Study of. Daveluy, R. Translated by Philip R. Alger, U. S. N., 125, 391.

Naval Strategy of the Russo-Japanese War, The. Cotten, L. A., 41.

Naval Training. II. Luce, S. B., 103.

Naval Training Service, U. S. Dillingham, A. C., 343.

Naval War College, The U. S. Luce, S. B., 559.

Naval War College, The U. S. (Concluded). Luce, S. B., 683.

Naval Warfare, The Genius of. II. Tactics. Daveluy, R. Translated by Philip R. Alger, U. S. N., 753, 991.

Navy, When was Ours Founded? A Criticism of Augustus C. Buell's "Paul Jones, Founder of the American Navy." Paullin, C. O., 255.

Neutralization, The Real Status of the Panama Canal as Regards. Knapp, H. S., 61.

Nixon, Lewis. Discussion, 587.

Nomogram for Compass Deviations, with an Elementary Exposition of the two Parallel Scale Nomograms. Pesci, G. Translated by Lieut. de Aquino, Brazilian Navy, 1043.

Norfolk Navy Yard, The Development of. Cunningham, A. C., 221.

Organization, The, of the Fleet. Hood, John, 825.

Panama Canal, The Real Status of, as Regards Neutralization. Knapp, H. S., 61.

Patterson, W. G. Discussion, 1146.

Paullin, C. O. Early Voyages of American Navy Vessels to the Orient, 429, 707, 1073.

Paullin, Charles Oscar. When was Our Navy Founded? A Criticism of Augustus C. Buell's "Paul Jones, Founder of the American Navy," 255.

Personnel, The Enlisted. Magruder, T. P., 375.

Pesci, Giuseppe, Professor, Royal Italian Naval Academy. A Nomogram for Compass Deviations, with an Elementary Exposition of the two Parallel Scale Nomograms. Translation by Lieutenant de Aquino, Brazilian Navy, 1043.

——— Notes on the Solution of the Triangle of Position without Trigonometrical Computation. Translated by F. W. Morrison, 529.

Pillsbury, J. E., Rear-Admiral, U. S. N. Wilkes' and d'Urville's Discoveries in Wilkes Land, 465.

Pope, R. E., Lieutenant, U. S. N. Discussion, 263.

Practice Cruise, Naval Academy, Its Organization Along Modern Lines. Foley, Paul, 239.

Professional Notes, 268, 595, 857, 1149.

Range Finders, Incorrect Adjustment of. Fiske, B. A., 1060.

Report of the Secretary and Treasurer of the U. S. Naval Institute, Annual, 334.

Rescue, An Unprecedented. Fiske, B. A., 957.

Resistance of Metals to Rapid Deformations, On a Method of Measuring the. Vieille, P. and Liouville, R. Translated by Philip R. Alger, U. S. N., 987.

Revolver Shooting. Lee, W. A., Jr., and Denny, A. D., 249.

Roberts, T. G., Naval Constructor, U. S. N. The Merchant Marine and the Navy, 1.

Russo-Japanese War, Naval Strategy of the. Cotten, L. A., 41.

Shipboard, More Light on. Gatewood, R. D., 1059.

Ship Propulsion, The Present Day Problem of. McNamee, L., 747.

Smokeless Powder, The Stability of. Strauss, J., 929.

Stability of Smokeless Powder, The. Strauss, J., 929.

Stirling, Yates, Jr., Lieut.-Commander, U. S. N. The Destroyer—Our Naval Weakness, 469.

Strauss, J., Commander, U. S. N. The Stability of Smokeless Powder, 929.

Strategy, A Study of Naval. Daveluy, R. Translated by Philip R. Alger, U. S. N., 125, 391.

Strategy of the Russo-Japanese War, Naval. Cotten, L. A., 41.

Taylor, D. W., Naval Constructor, U. S. N. A New Method for Determining the Final Diameter of a Ship, 501.

——— The Influence of Trim upon Resistance of Ships, 663.

Testing Explosives, Some Modern Developments in Methods of. Munroe, C. E., 805.

Torpedo-Boats, Concerning the Tactical Employment of. Vannutelli, L., Translated by H. B. McIntosh, U. S. N., 1101.

Training Gear, The Cutler-Hammer Manufacturing Company's Differential System of. Bullard, W. H. G., 543.

Training Service, U. S. Naval. Dillingham, A. C., 343.

Triangle of Position, Notes on the Solution of the, without Trigonometrical Computation. Pesci, G. Translated by F. W. Morrison, 529.

Trim, Economical, and Wasted Horsepower. White, W. R., 195.

Trim, The Influence of, Upon Resistance of Ships. Taylor, D. W., 663.

Vannutelli, L., Commander, Italian Navy. Concerning the Tactical Employment of Torpedo-Boats. Translation by H. B. McIntosh, 1101.

Velocity, Influence of, on the Law of Deformation of Metals, The. Vieille, P. and Liouville, R. Translated by Philip R. Alger, U. S. N., 985.

Vieille, P. and Liouville, R. On a Method of Measuring the Resistance of Metals to Rapid Deformations. Translation by P. R. Alger, 987.

——— The Influence of Velocity on the Law of Deformation of Metals. Translation by P. R. Alger, U. S. N., 985.

Voyages, Early, of American Naval Vessels to the Orient. Paullin, C. O., 429, 707, 1073.

War College, The U. S. Naval. Luce, S. B., 559.

War College, The U. S. Naval (Concluded). Luce, S. B., 683.

Wetmore, William Boerum. Discussion, 855.

White, William Russell, Lieut.-Commander, U. S. N. Wasted Horsepower and Economical Trim, 195.

Wilkes' and d'Urville's Discoveries in Wilkes Land. Pillsbury, J. E., 465.

Yarnell, H. E., Lieut.-Commander, U. S. N. Some Comments on Erosion and Ballistics, 965.

NOTICE.

The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It now enters upon its thirty-eighth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

On the subject of membership the Constitution reads as follows:

ARTICLE VII.

Sec. 1. The Institute shall consist of regular, life, honorary, and associate members.

Sec. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fees to the Secretary and Treasurer. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

Sec. 3. The Prize Essayist of each year shall be a life member without payment of fee.

Sec. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio,* an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

Sec. 5. Associate members shall be elected from Officers of the Army, Revenue Cutter Service, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

Sec. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

Sec. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: "Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing."

The Proceedings are published quarterly and anyone may subscribe for them. The annual subscription is $3.00; single copies, 75 cents. Annual dues for members and associate members, $2.00. Fee for life membership, $30.00.

All letters should be addressed U. S. Naval Institute, Annapolis, Md., and all checks, drafts, and money orders should be made payable to the same.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1911.

A prize of two hundred dollars, with a gold medal, and a life-membership in the Institute, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1912. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. If, in the opinion of the Board of Control, the best essay presented is not of sufficient merit to be awarded the prize, it may receive "Honorable Mention" or such other distinction as the Board may decide.

5. In case one or more essays receive "Honorable Mention," the writer of the first of them in order of merit will receive seventy-five dollars and a life-membership in the Institute.

6. Any essay not having received honorable mention may be published also, at the discretion of the Board of Control, but only with the consent of the author.

7. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

8. All essays submitted must be either typewritten or copied in a clear and legible hand.

9. In the event of the prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of the gold medal.

By direction of the Board of Control.

PHILIP R. ALGER,
Professor, U. S. N., Secretary and Treasurer.